RESEARCH CIRCULAR 291 JANUARY 1987

Ornamental Plants — 1987: A Summary of Research

The Ohio State University
Ohio Agricultural Research and Development Center

Wooster, Ohio

CONTENTS

**** ***** ****

Wound Healing in Street Trees 1

Evaluation of Flowering Crabapple Susceptibility to Apple Scab in Ohio--1986 3

Fertilizing Trees in the Landscape: A 15 Year Evaluation 8

Juniper Injury from Poast 11

Pre-Emergence Herbicides for Canna 13

An Evaluation of Cyanazine and Terbacil and Metolachlor Slow-Release Herbicide Tablets on Woody Landscape Crops 15

Tolerance of Landscape Vines to Selected Pre-Emergence Herbicides 17

Influences of Supplementary High Intensity Discharge Lighting Upon the Growth of 'Ringo' Geranium and 'Scarletta' Begonia Plug Propagated Plants 19

Fixed Costs of Operating Field Nurseries in Ohio by Size of Firm and Species of Plant 26

Costs of Producing Slow-Growing Evergreens (*Taxus*) in the Field by Size of Firm in Ohio 37

Costs of Producing Deciduous Shrubs (*Viburnum*) in the Field by Size of Firm in Ohio 45

Costs of Producing Shade Trees (*Acer rubrum*) in the Field by Size of Firm in Ohio 51

ON THE COVER: The white tablets in the containers of forsythia have been impregnated with slow release herbicides to evaluate weed control during the growing season from a single application. Work continues to find the proper combination of herbicides to yield season-long, broad-spectrum weed control without phytotoxicity as shown on the foliage of the plant on the right.

AGDEX 272-275-276/16-24-28 1-87-3M

Wound Healing in Street Trees

JAMES M. MARTIN[1] AND T. DAVIS SYDNOR[2]

ABSTRACT

This study was designed to determine if wound healing in street trees is more closely correlated with growth parameters or with the species. Twelve species were evaluated at OARDC, Wooster, OH and in Nashville, TN. Rate of healing was more closely correlated with species. Of the species evaluated, *Fraxinus pennsylvanica* and *Liquid ambar styraciflua* had more rapid wound closure than *Pyrus calleryana* 'Bradford', *Gleditsia triacanthos* var. *inermis*, and *Betula nigra*.

INTRODUCTION

Street trees are subjected to many stresses less common to trees in suburban landscape plantings. They are particularly vulnerable to mechanical damage, leading to decay of the heartwood and ultimately death (2,3). To reduce losses it would be beneficial to select trees that have a fast and effective wound healing response. This study was undertaken to determine whether genetic identity is a more reliable predictor of wound closure than commonly used growth parameters including electrical resistance readings taken with a Shigometer.

MATERIALS AND METHODS

In the Nashville portion of this study, ten species of street trees commonly used in the mid-south were selected. They were all growing in an urban environment no further than four feet from pavement. In the Wooster study, eight species of street trees were chosen at the OARDC Shade Tree Evaluation Plot. Five of the species were common to both sites; all trees had a trunk diameter of 10-15 cm at a height of 1.5 meters above the soil line. Wound holes made with a drill were 10 mm in diameter and 20 mm deep. The trees in the Nashville study were wounded at bud break on March 24, 1982; the trees in Wooster were wounded at bud break two consecutive years (1982 and 1983).

Caliper measurements were taken immediately after wounding and again at the end of the growing season. Twig extension data for the current season and two previous growing seasons were also gathered at that time. Wound closure was measured every two weeks from wounding to the end of the growing season.

Closure rate was computed by dividing 10 mm (size of the original wound) by the number of weeks it took for that wound to be completely closed. The rate was expressed as mm/wk. If the wound was not closed by the end of the season, then the number of millimeters that it had closed was divided by 30 (the number of weeks from wounding until callus growth stopped). Electrical resistance (ER) readings were taken using a Shigometer Model OZ-67 with the uninsulated, stainless steel probes.This type of reading has been used as an indicator of tree vigor (5). Species and cultivars evaluated included *Fraxinus pennsylvanica, Liquid ambar styraciflua, Betula nigra, Gleditsia triacanthos* var. inermis, *Pyrus calleryana* 'Bradford', *Acer rubrum, Platanus occidentalis, Quercus phellos, Prunus subhirlella* var. pendula, *Acer platanoides* and *Acer saccharum.*

RESULTS AND DISCUSSION

In both Nasvhille and OARDC studies *Fraxinus pennsylvanica* had the most rapid wound closure rate when compared to all other taxa, and *Pyrus calleryana* had the slowest (Table 1). Comparative rates of all taxa in the three studies are found in Tables 2, 3 and 4.

Growth parameters as a predictive factor for wound response proved to be erratic and ambiguous in these studies (Table 5). There was a general lack of consistency in the correlation of these parameters to wound closure. This is generally in agreement with Neely (4) and Gallagher (1).

These studies suggest that genetic identity is very important to wound closure. When compared to growth parameters, including E. R. readings, genetic identity is the most accurate predictor of wound closure rate, explaining 76 percent of the variation (Table 5). Therefore, in selecting species for street trees, the relative rate of wound closure may be yet another criteria to consider when selecting a specific plant for use in an urban site.

TABLE 1. Comparative wound closure rates for five tree species common to all three studies — Nashville, Tennessee, 1982, OARDC Shade Tree Evaluation Plot, 1982, 1983.

	Wound Closure Rates (mm/wk)			
Species	Nashville 1982	OARDC 1982	OARDC 1983	Avg. for 3 Studies
Fraxinus pennsylvanica	.93	1.25	.72	.97
Liquidambar styraciflua	.60	.92	.93	.82
Gleditsia triacanthos var. *inermis*	.43	.81	.74	.66
Betula nigra	.35	.83	.54	.57
Pyrus calleryana 'Bradford'	.24	.62	.52	:46

[1]Associate Professor of Agriculture, University of Western Kentucky, Bowling Green, KY.

[2]Professor of Horticulture, Department of Horticulture, Ohio State University and Ohio Agricultural Research and Development Center, Columbus, OH 43210.

TABLE 2. Wound closure for 10 taxa of street trees in Nashville, Tennessee, 1982.

Taxa	Closure Rate (mm/wk)
Fraxinus pennsylvanica	.93 A
Prunus subhirtella var. *pendula*	.76 B
Magnolia grandiflora	.75 B
Quercus phellos	.69 BC
Liquidambar styraciflua	.60 BC
Acer rubrum	.60 C
Platanus occidentalis	.58 C
Gleditsia triacanthos var. *inermis*	.43 D
Betula nigra	.35 DE
Pyrus calleryana 'Bradford'	.24 E
Mean	.59

Means followed by the same level are not significantly different when separated by Duncan's New Multiple Range Test - 0.5 level.

TABLE 3. Mean rates of wound closure for selected taxa of shade trees growing in Shade Tree Evaluation Plot, OARDC, 1982.

Taxa	Mean Closure Rate (mm/wk)
Fraxinus pennsylvanica	1.25 A
Liquidambar styraciflua	.92 AB
Acer platanoides	.86 B
Betula nigra	.83 BC
Gleditsia triacanthos var. *inermis*	.81 C
Pyrus calleryana 'Bradford'	.62 BC
Acer rubrum	.60 C
Acer saccharum	.53 C

Means followed by the same level are not significantly different when separated by Duncan's New Multiple Range Test - 0.5 level.

TABLE 4. Mean wound closure rates in mm/wk for six taxa of shade trees in the Shade Tree Evaluation Plot, OARDC, 1983.

Taxa	Mean Wound Closure Rate (mm/wk)
Liquidambar styraciflua	.93 A
Gleditsia triacanthos inermis 'Imperial'	.74 AB
Fraxinus pennsylvanica 'Summit'	.72 AB
Betula nigra	.54 BC
Pyrus calleryana 'Bradford'	.52 BC
Acer saccharum	.33 C

Means followed by the same level are not significantly different when separated by Duncan's New Multiple Range Test - 0.5 level.

TABLE 5. Stepwise multiple regression data for 10 taxa of street trees, Nashville, Tennessee, 1982; dependent variable is rate of wound closure.

Independent Variables	R^2
Twig extension 1981	.12
Twig extension 1982	.11
Caliper increase	.40
Twig extension 1981 and 1982	.12
Twig extension 1981 and caliper increase	.42
Twig extension 1982 and caliper increase	.40
Twig extension 1981, 1982 and caliper increase	.44
Species	.76
Species and caliper increase	.76
Species and twig extension 1982	.76
Species, twig extension 1982 and caliper increase	.76

LITERATURE CITED

1. Gallagher, Peter W. 1982. Genetic variation and growth regulator effects on wound response among *Acer* and *Populus* taxa. Dissertation, The Ohio State University.
2. Kramer, Paul J. and Theodore T. Kozlowski. 1979. Physiology of woody plants. Academic Press, N.Y., N.Y.
3. Manion, Paul D. and Robert A. Zabel. 1979. Stem decay perspectives — an introduction to the mechanics of tree defense and decay patterns. Phytopathology 69:1136-1138.
4. Merrill, W. and Alex L. Shigo. 1979. An expanded concept of tree decay. Phytopathology 69:1158-1160.
5. Shigo, Alex L., Richard Campana, Fay Hyland, and Jan Anderson. 1980. Anatomy of elms injected to control Dutch elm disease. J. Arboriculture 6:96-100.

Evaluation of Flowering Crabapple Susceptibility to Apple Scab in Ohio -1986

ELTON M. SMITH and SHARON A. TREASTER[1]

ABSTRACT

One hundred eleven flowering crabapple (*Malus* species) selections were found to be highly resistant or resistant to apple scab in a 1986 Ohio survey. Conversely, there were 77 selections observed to be susceptible or highly susceptible to apple scab. These figures compare to 127 highly resistant or resistant and 79 susceptible or highly susceptible in 1985 in a year when apple scab was also relatively light due to dry weather conditions in early spring.

INTRODUCTION

Many of the flowering crabapples grown in Ohio are susceptible to apple scab (*Venturia inequalis*), a disease which can be devastating to trees over time. The first symptoms of the disease are olive gray spots on the foliage often leading to yellowing and defoliation of susceptible types. Defoliation year after year weakens trees eventually leading to winter injury and reduced bloom in succeeding years.

Apple scab can be prevented with costly fungicide treatments or by choosing resistant selections at the time of the initial planting.

A significant number of flowering crabapple selections are resistant or highly resistant to apple scab and should be selected for future production.

This survey continues the annual evaluations of flowering crabapple selections produced in Ohio for tolerance to apple scab. A statewide evaluation allows growers, retailers and landscapers to know what selections have proven to be resistant and which selections are too susceptible to diseases.

MATERIALS AND METHODS

A survey of Ohio nursery and arboretum personnel was conducted in August 1986. Apple scab severity was rated and the presence of other diseases such as cedar apple rust, fireblight, and frog eye leaf spot were noted. Ratings were not given to the latter three diseases because they are rarely serious enough in Ohio to discontinue the planting of a species, hybrid, or cultivar.

Apple scab infestation was rated as follows: HR = highly resistant -- no indication of disease; R= resistant --mild infection with no defoliation; S = susceptible -- medium infection with only slight defoliation; and HS = highly susceptible -- heavy infection often accompanied by considerable defoliation. More than one notation may appear in the table for a given selection because severity of infection varied from location to location. This variation was most likely due to differences in time and amount of rainfall and average relative humidity.

RESULTS AND DISCUSSION

Previous observations by the authors (2,3,4) indicate some degree of variability from year to year in the presence of apple scab. Severity is usually dependent on frequency and amount of rainfall in early spring. Rainfall in April 1986 in most of Ohio was unusually light with 50-year record low amounts recorded in some localities. Rainfall was about average in May and June in most areas and low again in late July and August.

In 1986 there were 111 selections rated highly resistant or resistant while 77 were susceptible or highly susceptible (Table 1). This compares favorably to 127 resistant and 79 susceptible in 1985. However, in 1984, the last wet season, there were 89 selections resistant and 114 susceptible (3).

In 1986, the most disease resistant selections (apple scab, cedar apple rust, fireblight, frog eye leaf spot, and mildew) were: Malus 'Adams,' baccata 'Midwest,' 'Beverly,' 'Bob White,' 'Burgundy,' 'Centennial,' 'Chestnut,' 'Chilko,' 'Christmas Holly,' 'Dawsoniana,' 'Dolgo,' 'Donald Wyman,' 'Dorothy Rowe,' 'Flexilis,' 'Floribunda' florentina, 'Fusca,' 'Girard's Dwarf Weeping,' 'Golden Gem,' 'Gwendolyn,' halliana and h. 'Parkmanii'. Also, hupehensis, 'Joan,' 'Kibele,' 'Kola,' 'Liset,' 'Makamik,' 'Marshall Oyama,' 'Mary Potter,' micromalus, 'Ormiston Ray,' 'Patricia,' 'Pink Beauty,' 'Prarifire,' 'Prince Georges,' 'Prof. Springer,' prunifolia 'Fastigiata,' p. 'Pendula,' 'Red Jade,' 'Red Jewel,' robusta, r. 'Persicifolia,' 'Rosseau,' 'Rosybloom,' sargenti, s. 'Rose Low,' 'Scugog,' 'Selkirk,' 'Sentinel,' sieboldi, and s. 'Arborescens,' sikkimensis, 'Silver Moon,' 'Sissipuk,' 'Snowcap,' spectabilis 'Albi-Plena,' Strawberry 'Parfait,' 'Sugartyme,' 'Sundog,' sylvestris 'Plena,' 'Trail,' 'White Angel,' yunnanensis 'Veitchi,' y. 'Veitch's Scarlet' and zumi 'Calocarpa'.

A number of others, not listed above, were rated resistant to apple scab and remain good selections for Ohio. However, those selections rated susceptible or highly susceptible should be used with extreme caution.

The following flowering crabapples were highly susceptible to apple scab in 1986 and previous years and should be discontinued from planting in Ohio: 'Amisk,' arnoldiana, 'Arrow,' 'Ellen Gerhart,' 'Hopa,' 'Irene,' 'Jay Darling,' 'Leslie,' 'Pink Perfection,' 'Purple Wave,' purpurea 'Eleyi,' 'Strathmore,' 'Tanner' and 'Vanguard'.

[1]Professor and Technician, Department of Horticulture, OSU

Additional information on flowers, fruits, foliage, and growth habit can be obtained from the publication "The Flowering Crabapple - A Tree for All Seasons" (1) or by visiting arboretums in late April through early May. Excellent collections of flowering crabapples can be found in Ohio in The Dawes Arboretum in Newark, Holden Arboretum in Kirtland Hills, and the Secrest Arboretum in Wooster.

LITERATURE CITED

1. Brewer, J.E. L.P. Nichols, C.C. Powell, and E.M. Smith, 1979. The flowering crabapple - a tree for all seasons. Coop. Ext. Serv. of Northeast States, NE 223, NCR 78.
2. Smith, Elton M. 1979. A 10-year evaluation of flowering crabapple susceptibility to apple scab in Ohio. Ohio Agri. Res. and Dev. Ctr., Res. Cir. 246. Ornamental Plants -1979: A Summary of Research, pp. 36-39.
3. Smith, Elton M. 1984. Evaluation of flowering crabapple susceptibility to apple scab in Ohio -1984. Ohio Agr. Res. and Dev. Ctr., Res. Cir. 284, Ornamental Plants -1984: A Summary of Research, pp. 19-22.
4. Smith, Elton M. and Sharon A. Treaster. 1985. Evaluation of flowering crabapple susceptibility to apple scab in Ohio -1985. Ohio Agr. Res. and Dev. Ctr. Res. Circ. 289, Ornamental Plants - 1986: A Summary of Research, pp. 4-8.

TABLE 1. Susceptibility of Flowering Crabapples to Apple Scab-1986.

	Apple Scab Rating*				
Species, Hybrid or Cultivar	**HR**	**R**	**S**	**HS**	**Other Diseases Noted**
'Adams'	X				
M. x adstringens			X		
'Almey'			X		
'American Beauty'			X		
'Amisk'				X	
'Arnold Arboretum'		X	X		
M. x arnoldiana				X	
'Arrow'				X	
M. x atrosanguinea				X	
M. baccata			X		
M. baccata 'Ceratocarpa'				X	
M. baccata columnaris	X	X			
M. baccata 'Jackii'	X	X			Fireblight
M. baccata var. Mandshurica		X			
M. baccata 'Midwest'	X				
'Barbara Ann'				X	
'Beverly'	X				
'Bob White'	X				
'Brandywine'	X	X			Cedar-Apple Rust
M. brevipes				X	
'Burgundy'	X				
'Candied Apple'		X			
'Cashmere'			X		
'Centennial'	X				
'Centurion'			X		
'Cheal's Crimson'			X	X	
'Chestnut'	X				
'Chilko'	X				
'Christmas Holly'	X				
'Coralburst'		X			Frog Eye Leaf Spot
M. coronaria 'Charlottae'		X	X		
M. coronaria 'Nieuwlandiana'			X		Cedar Apple Rust
'Cowichan'				X	
'Crimson Brilliant'			X	X	
'Dainty'			X		
'David'	X				Fireblight
'Dawsoniana'	X				
'Dolgo'	X				
'Donald Wyman'	X				
'Dorothea'			X	X	
'Dorothy Rowe'	X				
'Ellen Gerhart'				X	
'Evelyn'			X		
'Flame'		X	X		
'Flexilis'	X				
M. florentina	X				
M. floribunda	X				
'Fusca'	X				
'Girard's Dwarf Weeping'	X				

* HR = Highly Resistant, R = Resistant, S = Susceptible and HS = Highly Susceptible.

TABLE 1 (continued). Susceptibility of Flowering Crabapples to Apple Scab-1986

Species, Hybrid or Cultivar	Apple Scab Rating* HR	R	S	HS	Other Diseases Noted
'Geneva'		X			
'Goldfinch'				X	
M. glaucescens		X			
M. gloriosa		X			
'Golden Gem'	X				
'Golden Hornet'	X				Fireblight
'Gwendolyn'	X				
M. halliana	X				
M. halliana 'Parkmanii'	X				
'Harvest Gold'		X			Fireblight
'Henningi'		X			
'Henry Dupont'		X			
'Hopa'				X	
'Hopa Austrian'			X		
'Hopa Dwarf'	X				
'Hopa Rosea'			X		
M. hupehensis	X				
'Indian Magic'		X	X		
'Indian Summer'		X	X		
M. ioensis				X	
M. ioensis 'Klehms'	X				Cedar Apple Rust
M. ioensis 'Plena'			X		
'Klehms Improved'	X				Cedar Apple Rust
'Irene'				X	
'Jay Darling'				X	
'Joan'	X				
'Jewelberry'		X			
'Katherine'			X		
'Kibele'	X				
'Kirghisorum'	X				
M. 'Kola'	X				
M. lancifolia			X		Cedar Apple Rust
'Leslie'				X	
'Liset'	X				
'Madonna'		X			Fireblight
M. x magdeburgensis		X	X		
'Makamik'	X				
'Marshall Oyama'	X				
'Mary Potter'	X				
'Masek'				X	
M. x micromalus	X				
'Molton Lava'	X	X			
M. 'Neville Copeman'				X	
'Oakes'				X	
'Oekonomierat Echtermeyer'				X	
'Ormiston Roy'	X				
'Patricia'	X				
'Pink Beauty'	X				
'Pink Cascade'		X			
'Pink Flame'		X	X		
'Pink Perfection'				X	
'Pink Spires'		X	X		
'Pink Weeper'			X		
'Prairie Rose'	X				Cedar Apple Rust
'Prairifire'	X				
'Pretty Marjorie'		X			
'Prince Georges'	X				
'Profusion'		X	X		
'Prof. Springer'	X				
M. prunifolia				X	
M. prunifolia 'Fastigiata'	X				
M. prunifolia 'Pendula'	X				
M. pumila 'Elise Rathke'			X		
M. pumila 'Niedzetzkayana'				X	

* HR = Highly Resistant, R = Resistant, S = Susceptible and HS = Highly Susceptible.

TABLE 1 (continued). Susceptibility of Flowering Crabapples to Apple Scab-1986

Species, Hybrid or Cultivar	Apple Scab Rating* HR	R	S	HS	Other Diseases Noted
M. pumila 'Paradise Foleus Aureus'	X				Mildew
'Purple Wave'				X	
M. purpurea				X	
M. purpurea 'Aldenhamensis'			X	X	
M. purpurea 'Eleyi'			X		
M. purpurea 'Lemoinei'				X	
M. 'Pygmy'				X	
'Radiant'			X	X	
'Ralph Shay'		X			
'Red Baron'			X		Mildew
'Red Bud'	X				
'Red Edinburgh'				X	
'Red Flesh'		X			
'Red Jade'	X				
'Red Jewel'	X				
'Red Silver'	X				Frog Eye Leaf Spot
'Red Splendor'		X			
'Ringo'		X			
'Robinson'		X	X		
M. x robusta	X				
M. x robusta 'Erecta'		X	X		
M. rubusta 'Persicifolia'	X				
'Rose Tea'	X				Fireblight
'Rosseau'	X				
'Rosybloom'	X				
'Royal Ruby'		X	X		
'Royalty'			X		
'Ruby Luster'			X		
'Rudolf'		X	X		
M. sargentii	X				
M. sargentii 'Rosea'	X	X			
M. sargentii 'Rose Low'	X				
M. x scheideckeri		X	X		
M. x scheideckeri 'Hilleri'			X		
'Scugog'	X				
'Selkirk'	X				
'Sentinel'	X				
'Shakespeare'				X	
M. sieboldi	X				
M. sieboldi 'Arborescens'	X				
M. sikkimensis	X				
'Silver Moon'	X				
'Simcoe'		X			
'Sissipuk'	X				
'Snowcap'	X				
'Snowcloud'				X	
'Snowdrift'		X	X		
'Snowmagic'			X		
M. x soulardii				X	
'Sparkler'				X	
M. spectabilis				X	
M. spectabilis 'Albi-Plena'	X				
M. spectabilis 'Van Eseltine'			X		
'Spring Snow'		X	X		
'Strathmore'				X	Frog Eye Leaf Spot
'Strawberry Parfait'	X				
M. x sublobata		X			
'Sugartyme'	X				
'Sundog'	X				
M. sylvestris 'Plena'	X				
'Tanner'				X	
M. toringoides			X		
M. toringoides 'Macrocarpa'				X	
'Trail'	X				
M. tschonoski	X				Fireblight

* HR = Highly Resistant, R = Resistant, S = Susceptible and HS = Highly Susceptible.

TABLE 1 (continued). Susceptibility of Flowering Crabapples to Apple Scab-1986

Species, Hybrid or Cultivar	Apple Scab Rating* HR	R	S	HS	Other Diseases Noted
'Turesi'			X		
'Valley City #4'				X	Frog Eye Leaf Spot
'Vanguard'				X	
'Velvet Pillar'			X	X	
'Wabiskaw'			X		
'White Angel'	X				
'White Candle'			X	X	
'White Cascade'		X			
'Wickson'		X			Fireblight
'Wilson'			X		
'Winter Gold'			X		
'Wooster No. 1'		X			
M. yunnanensis 'Veitchi'		X			
M. yunnanensis 'Veitch's Scarlet'	X				
M. zumi	X				Frog Eye Leaf Spot
M. zumi 'Calocarpa'	X				

* HR = Highly Resistant, R = Resistant, S = Susceptible and HS = Highly Susceptible.

Fertilizing Trees in the Landscape: A 15-Year Evaluation

ELTON M. SMITH and SHARON A. TREASTER[1]

ABSTRACT

After 15 years, growth of *Tilia cordata* 'Select', *Malus* 'Snowdrift' and *Acer saccharum* ''Monumentale' was not affected by fertiilizer placement. All fertilizer treatments of *Tilia* resulted in trunk caliper increases but there were no differences among rates of application. Although treatment differences were observed in *Malus* and *Acer* through 12 years, there were no trunk caliper, height or branch diameter differences between control and treated trees after 15 years.

INTRODUCTION

Many trees planted around newly constructed residences and commercial buildings are located in soils less than desirable for plant growth. These sites are often composed of subsoils which are typically low in organic matter, heavily compacted, and poorly drained. For these reasons, trees in the landscape must be fertilized regularly to survive when planted in poor soils. A well-fertilized tree will generally be more resistant to insect and disease problems and more tolerant of winter conditions (8).

Fertilizer recommendations for trees historically have been based on trunk caliper. In recent literature, however, the basis has changed to soil surface area (1,3,4). Nutrition research and subsequent recommendations indicate that optimum tree growth will result from the application of from 2-3 lb N/1000 sq ft/yr to 6 lb N/1000 sq ft (5,6,9,10,11,12). Tree growth appears to be more directly related to fertilizer rate than to differences in fertilizer placement (2,7).

The objectives of this research were to evaluate tree growth, in sites similar to many home landscapes, as a function of four nitrogen levels and two placement methods for an extended period of years.

[1]Professor and Research Technician, Dept. of Horticulture, OSU

MATERIALS AND METHODS

Branched whips of *Tilia cordata* 'Select' -Improved Littleleaf Linden, *Malus* 'Snowdrift' -Snowdrift Flowering Crabapple, and *Acer saccharum* 'Monumentale' - Sentry Sugar Maple were planted in April 1969. The trees were grown in sod culture and the turf mowed as needed. There were 12 trees per fertilizer treatment/species.

All trees received 6 lb of actual phosphorus and potassium per 1000 sq ft in May 1971 and in April of 1974, 1977, 1980, and 1983. The nitrogen, in the form of ammonium nitrate, was applied at the same time at either 0,3,6, or 9 lb actual N/1000 sq ft. One-half of the treated trees received nitrogen as a surface application while the remainder were treated via drill hole application. The 20 holes per tree, drilled with a 2-inch power auger to a 12-inch depth, were spaced in two concentric rings in a 100 sq ft area around each tree. In the drill hole treatments, the fertilizer was mixed with calcined clay marketed as Sta-red-bits. One treatment consisted of a drill hole treatment filled with calcined clay without fertilizer to evaluate the effects from aeration alone.

This investigation was conducted utilizing a randomized block design with three trees per treatment and four replications. The data were analyzed by ANOVA using Duncan's Multiple Range Test at the 5 percent level of significance for mean separation.

RESULTS AND DISCUSSION

As shown in Table 1 all fertilizer treatments including the holes only treatment resulted in significantly increased trunk caliper growth of *Tilia* when compared to untreated trees after 15 years. Average caliper growth of *Tilia* was larger than *Malus* or *Acer*. The trunk splitting of control trees observed in 1974(8) as a result of nitrogen stress was still evident in 1986. The control trees of *Tilia* were approximately the same caliper size as the *Malus* and *Acer* control trees.

TABLE 1. Average caliper growth in inches of Littleleaf Linden after 3, 6, 9, 12 and 15 years of nitrogen fertilizer treatment.

Treatment	3 years	6 years	9 years	12 years	15 years	Ave./Yr.
Control, No holes, No N	2.0*	3.03a†	4.84b	7.10b	8.0b	0.53
Holes Only plus Calcined Clay	2.9	4.33b	6.38a	8.73a	11.3a	0.75
3 lb N Drill Hole	3.0	4.58bc	6.71a	8.73a	11.3a	0.73
6 lb N Drill Hole	3.0	4.55bc	6.83a	9.14a	11.3a	0.75
9 lb N Drill Hole	3.0	4.80cd	7.03a	8.98a	11.3a	0.75
3 lb N Surface	3.0	4.78cd	6.90a	9.33a	11.9a	0.79
6 lb N Surface	3.2	4.90cd	6.88a	9.09a	11.3a	0.75
9 lb N Surface	3.1	5.08d	7.49a	9.93a	12.1a	0.83

* Each figure represents the average of 12 trees measured 1 foot from the soil line.
† Letters followed by dissimilar letters within columns are significantly different at the 5 percent level.

With the exception of the 3 lb N drill hole and 6 lb surface all other fertilizer treatments resulted in significantly larger branch diameter spread than control trees (Table 4). There were no height differences as a function of treatment.

Increases in caliper growth of *Malus* from fertilizer treatment was evident through 12 but not after 15 years. There were no differences among treatments after 15 years in *Malus* height or branch spread diameter. This is not surprising in that branch spread diameter measurements after 12 years (11) were approximately the same (16.1-19.0′) as those after 15 years (16.6-19.4′). With the trees reaching mature size in 1983 one might not expect significant growth differences in future evaluations.

Fertilizer treatments resulted in differences in caliper growth of Sentry Sugar Maple through 12 years of research (11) but not after 15 years as shown in Table 1. There were no treatment differences in height or diameter branch spread of Maple after 15 years. (Table 2).

There were no growth differences in any plant species between drill hole and surface treatments. This represents a change from earlier evaluations (9,10) when rates and placement did influence growth. Apparently, as trees approach or reach mature size, fertilizer placement and rates of fertilizer used in this study may not be reflected in growth differences as in early years after planting. This does not suggest that regular fertilization is not important for tree health but that significant increases in growth may not occur when a large tree is fertilized.

TABLE 2. Average caliper growth in inches of Snowdrift Flowering Crabapple after 3, 6, 9, 12 and 15 years of nitrogen fertilizer treatment.

Treatment	3 years	6 years	9 years	12 years	15 years	Ave./Yr.
Control, No Holes, No N	2.7*	3.40a†	5.19c	6.35cd	7.4a	0.49
Holes Only Plus Calcined Clay	3.0	4.30b	5.53abc	6.21d	8.0a	0.53
3 lb N Drill Hole	2.8	4.35b	5.28bc	6.68bcd	7.7a	0.51
6 lb N Drill Hole	3.1	4.83cd	6.23ab	6.88abcd	8.3a	0.55
9 lb N Drill Hole	3.1	4.85cd	6.23ab	7.90a	8.6a	0.57
3 lb N Surface	2.8	4.50bc	5.40abc	6.78bcd	7.9a	0.53
6 lb N Surface	3.3	5.13d	6.39a	7.74ab	8.5a	0.57
9 lb N Surface	3.1	4.85cd	6.17ab	7.43abc	8.6a	0.57

* Each figure represents the average of 12 trees measured 1 foot from the soil line.
† Letters followed by dissimilar letters within columns are significantly different at the 5 percent level.

TABLE 3. Average caliper growth in inches of Sentry Maple after 3, 6, 9, 12 and 15 years of nitrogen fertilizer treatment.

Treatment	3 years	6 years	9 years	12 years	15 years	Ave./Yr.
Control, No Holes, No N	2.5*	3.38a†	4.71bc	5.87c	7.9a	0.53
Holes only plus Calcined Clay	2.8	3.50ab	4.56c	5.90c	8.1a	0.54
3 lb N Drill Hole	2.9	4.00cd	5.45abc	7.15ab	8.9a	0.59
6 lb N Drill Hole	3.2	4.50e	6.11a	7.64a	9.8a	0.65
9 lb N Drill Hole	2.9	3.95bcd	5.50ab	6.99abc	8.7a	0.58
3 lb N Surface	2.8	3.53ab	4.93bc	6.23bc	8.7a	0.58
6 lb N Surface	2.9	3.88bc	5.36abc	6.88abc	8.4a	0.56
9 lb N Surface	3.1	4.35cd	5.98a	7.50a	9.2a	0.61

* Each figure represents the average of 12 trees measured 1 foot from the soil line.
† Letters followed by dissimilar letters within columns are significantly different at the 5 percent level.

TABLE 4. Tree height and diameter of branch spread following 15 years of nitrogen fertilizer.

	Littleleaf Linden		Snowdrift Crabapple		Sentry Sugar Maple	
Treatment	Height	Branch Dia.	Height	Branch Dia.	Height	Branch Dia.
Control, No Holes, No N	26.0a*	16.3†	16.0a	16.7a	32.2a	20.4a
Holes only plus Calcined Clay	29.7a	20.0ab	16.6a	17.6a	32.6a	20.0a
3 lb N Drill Hole	28.6a	29.4ab	15.8a	17.0a	34.3a	22.4a
6 lb N Drill Hole	30.2a	21.2a	16.9a	18.7a	34.7a	23.4a
9 lb N Drill Hole	29.1a	21.0a	16.9a	19.0a	33.7a	21.6a
3 lb N Surface	30.5a	20.6a	16.4a	17.9a	34.4a	21.3a
6 lb N Surface	28.4a	19.7ab	26.3a	28.9a	31.2a	19.9a
9 lb N Surface	29.9a	21.5a	16.8a	19.4a	32.2a	23.2a

* Feet
† Letters followed by dissimilar letters within columns are significantly different at the 5 percent level.

LITERATURE CITED

1. Bettes, Russell, M. 1972. Feeding shade and ornamental trees. Amer. Nur. Oct. 1, pp. 14, 100-102
2. Himelick, E. B. and Dan Neely. 1966. Tree fertilization. Amer. Nur. 154(21):11.
3. Janne, Everett E. 1971. Under the spreading shade tree. Texas Agri. Prog. 17(1):21-23
4. Koelling, Melvin R. and J. James Kielbaso. 1974. Fertilizing trees in the landscape-progress report. Ohio Agri. Res. and Dev. Ctr., Res. Sum. 79 pp. 61-62.
5. Smith, Elton M. and Kenneth W. Reisch. 1974. Fertilizing trees in the landscape—progress report. Ohio Agri. Res. and Dev. Ctr., Res. Sum. 79, pp. 61-62.
6. Smith, Elton M. 1974. A study of the economics of fertilizing trees in the nursery. Ohio Agri. Res. and Dev. Ctr., Res. Sum. 79, pp. 59-60.
7. Smith, Elton M. 1973. Effects of fertilizer placement on tree growth. Ohio Agri. Res and Dev. Ctr., Res. Sum. 71, pp. 39-40
8. Smith, Elton M. 1974. Fertilization reduces trunk splitting of *Tilia cordata*. Ohio Coop. Ext. Serv., Nursery Notes, 7(6):1.
9. Smith, Elton M. 1978. Fertilizing trees in the landscape: A 6-year evaluation. Ohio Agri. Res. and Dev. Ctr., Res. Circ. 236, Ornamental Plants-1978: A Summary of Research, pp. 38-40.
10. Smith, Elton M. 1982. Fertilizing trees in the landscape: A 9-year evaluation. Ohio Agri. Res. and Dev. Ctr., Res. Circ. 263, Ornamental Plants-1981:A Summary of Research, pp.11-13.
11. Smith, Elton M.and Sharon A. Treaster. 1984. Fertilizing trees in the landscape. A 12-year evaluation. Ohio Agr. Res. and Dev. Ctr. Circ. 279, Ornamental Plants-1984: A Summary of Research, pp.1-4.

Juniper Injury from Poast

ELTON M. SMITH and SHARON A. TREASTER[1]

ABSTRACT

Poast, a post-emergence grass herbicide, has been injurious to Junipers with a blue foliage coloration. The objective of this research was to determine whether Poast or the crop oil additive caused the phytotoxicity in over-the-top spray applications. Blue Rug and Broadmoor Junipers, both low-growing, spreading cultivars with blue coloration, were injured to a greater degree when Poast alone was applied than when only the crop oil was applied. Injury was more severe at three months than at earlier evaluations.

INTRODUCTION

Poast, a selective post-emergence grass herbicide, has been used extensively by the nursery and grounds maintenance industries the past several years as an over-the-top application on small shrubs, ground covers and selected herbaceous crops for perennial grass control. Current recommendations indicate Junipers are labelled for use with Poast but warning is indicated (1) if plants have blue foliage. Research by the authors (2) has confirmed injury to blue foliage Junipers when Poast and crop oil was applied. It has generally been thought that the crop oil caused the damage similar to a dormant oil type injury. The objective of this study was to ascertain if the herbicide Poast or the crop oil amendment caused the foliar discoloration.

MATERIALS AND METHODS

Plants selected for the evaluation included *Juniperus horizontalis* 'Wiltoni' - Blue Rug Juniper, which has been shown susceptibile to injury previously and *Juniperus sabina* 'Broadmoor' - Broadmoor Juniper, another low growing selection with a blue-green color. Both juniper cultivars were 12-inch plants growing in one-gallon containers in pinebark-peat-sand (6-3-1 by volume) medium. Plants were established in containers in 1985, fertilized with Osmocote 18-6-12 at recommended rates on May 20, 1986, and watered as needed throughout the growing season.

Treatments were control - no spray; Poast at 3.0 percent (without oil); Poast at 3.0 percent plus crop oil (1 quart/100 gal.) and crop oil (1 qt/100 gal.) alone.

Plants were treated May 27, 1986. Herbicides were applied with a pressure tank sprayer at 40 psi and the plants sprayed to run-off. Evaluations were conducted one month, (June 24th), two months (July 22nd), and three months (August 22nd) from treatment. Plants were evaluated on a 1-10 scale with 10 indicating no injury 1 equal to death and values above 7 considered commercially acceptable.

There were three plants per replication and three replications per treatment.

RESULTS AND DISCUSSION

Injury ratings three months from treatment to both cultivars of Juniper were similar and below acceptable levels (Table 1). The cause of the injury was the herbicide Poast itself and not the crop oil amendment. In every evaluation, the Poast treatments discolored the blue foliage to a light green throughout the plant. There was no yellowing or browning of the foliage or stem tissue with any treatment, however, new growth following herbicide treatment was delayed by two weeks. Consequently, the control and oil treated plants were larger at the conclusion of the study.

There was very slight discoloration of foliage of Broadmoor Juniper with oil alone. When crop oil was combined with Poast or Poast without the crop oil was sprayed, the injury in July and later in August was always more pronounced than crop oil only treatments. The injury in July and August caused by the Poast treatments in both Juniper cultivars was below that considered acceptable by commercial growers. The vegetative or total growth of the plants in Poast treatments was different from the control or oil treatments over the course of the summer indicating that growth can be reduced and the color of plants will be different.

These results were to some degree surprising because it had been thought that the juniper phytotoxicity was being caused by the crop oil. In fact, the company that markets Poast had been experimenting with products to substitute for the crop oil to reduce the chances for injury and not decrease effectiveness of the herbicide.

[1]Professor and Technician, Department of Horticulture, OSU

TABLE 1. Phytotoxicity of Juniper to Poast.

Treatment	Phytotoxicity: Blue Rug Juniper June 24	July 22	Aug. 22	Broadmoor Juniper June 24	July 22	Aug. 22
Check	10.0	10.0	10.0	10.0	10.0	10.0
Poast	6.0	5.0	5.0	8.3	6.0	5.0
Oil	10.0	10.0	10.0	8.0	9.0	9.0
Poast+Oil	8.0	6.0	5.3	7.7	6.0	5.0

Visual scale: 1-10 with 1 = death, 10 = no injury and 7 or above acceptable.

The commercial significance of these findings indicate that users of Poast must be extremely careful not to apply the herbicide on blue conifers such as Juniper, and probably other blue-colored species as blue spruce, Boulevard chamaecyparis, and white fir.

LITERATURE CITED

1. Smith, Elton M. 1986. Chemical weed control in commercial nursery and landscape plantings. MM-297 Ohio Coop. Ext. Serv. The Ohio State Univ.
2. Smith, Elton M. and Sharon A. Treaster. 1984. Tolerance of landscape crops to Fusilade and Poast. Orn. Plants-1984: A Sum. of Res., Ohio Agr. Res. and Dev. Ctr., Res. Circ. 279:11-13.

Pre-Emergence Herbicides for Canna

ELTON M. SMITH and SHARON A. TREASTER[1]

ABSTRACT

The objective of this study was to determine whether Dacthal or Treflan could be utilized for weed control in *Canna* x *generalis* 'Rosamond Cole' plantings without causing significant phytotoxicity. Both pre-emergence herbicides controlled annual grass and broadleaf weeds for 10 weeks after planting. Dacthal at the recommended rate of 10.0 lbs. aia caused no visible plant phytotoxicity. Dacthal at the 2X rate of (20.0 lbs. aia) caused very slight foliar spotting at the first two evaluation dates but the plants outgrew the injury. Treflan at 4.0 and 8.0 lb. aia rates (1X and 2X, respectively) caused some foliar spotting by the initial evaluation on May 30 but the plants were not injured in subsequent evaluations.

INTRODUCTION

Canna is a popular summer flowering bulbous crop which is commonly planted in mass plantings in the commercial landscape and by the general gardening public alike. Unfortunately there are no registered pre-emergence herbicides to use for weed control with this crop. The objective of this evaluation was to ascertain the effectiveness and phytotoxicity of Dacthal and Treflan with Canna.

Previous research by the authors (1,2,3) indicated that canna has a significant degree of tolerance to both Dacthal (3) and Treflan (2) but neither compound is yet labelled by the EPA for use with canna.

[1]Professor and Technician, Dept. of Horticulture, OSU

MATERIALS AND METHODS

The crop selected for this evaluation was *Canna* x *generalis* 'Rosamond Cole' — Rosamond Cole Canna.

The rhizomes were planted April 25, 1986 in The Ohio State University Field Research Nursery. The soil is a Brookston silt clay loam. The plants were fertilized two weeks after planting and irrigated as needed during the growing season.

The herbicides selected for this study were Dacthal (DCPA) applied at 10.0 and 20.0 lbs aia and Treflan (trifluralin) at 4.0 and 8.0 lbs aia. Herbicides were applied May 2, 1986 in a three-foot band in the row. There were three plants per treatment and four replications of each treatment.

Plants were evaluated May 30 (four weeks), June 6 (five weeks), June 27 (eight weeks), and July 14 (10 weeks). Weed control and plant phytotoxicity were evaluated on a visual scale of 1-10 with 10 best and 7 or above acceptable.

RESULTS AND DISCUSSION

Weed control with both pre-emergence herbicides at all rates was acceptable for the entire 10-weeks of the study (Table 1). Dacthal was beginning to lose effectiveness at the 10-week point especially at the 10.0 lbs aia rate. Treflan was equally effective in controlling weeds after 10 weeks as it was earlier in the season; suggesting that control may have been extended further. The weeds most prevalent in the control plots and controlled by the herbicides included foxtail, crabgrass, lambsquarters, and purslane.

Very slight foliar injury was observed at the four-week evaluation with Dacthal at the 20.0 lbs aia rate and Treflan at both the 4.0 and 8.0 lbs aia rates (Table 2). Plants

TABLE 1. Pre-emergence Weed Control in Canna Planted May 2, 1986.

Treatment	Rate lbs. aia	Evaluation Dates			
		May 30	June 6	June 27	July 14
Check	—	9.0*	8.0	5.5	5.5
Dacthal	10.0	8.8	9.0	8.3	7.8
Dacthal	20.0	9.8	9.3	8.5	8.5
Treflan	4.0	9.8	9.8	9.8	9.8
Treflan	8.0	10.0	10.0	10.0	10.0

* Visual weed control rating: 1-10, with values above 7 acceptable and 10 best.

TABLE. 2. Tolerance of Canna to Dacthal and Treflan, 1986.

Treatment	Rate lbs. aia	Evaluation Dates			
		May 30	June 6	June 27	July 14
Check	—	10.0*	10.0	10.0	10.0
Dacthal	10.0	10.0	10.0	10.0	10.0
Dacthal	20.0	9.8	9.8	10.0	10.0
Treflan	4.0	9.8	10.0	10.0	10.0
Treflan	8.0	9.8	10.0	10.0	10.0

* Visual phytotoxicity rating: 1-10 with values above 7 acceptable and 10 best (no phytotoxicity).

recovered nicely as the season progressed and there were no visual symptoms in any evaluation after five weeks. Commercially, both Treflan and Dacthal could be safely used with 'Rosamond Cole' canna at the recommended rate if a label existed for canna.

LITERATURE CITED

1. Smith, Elton M. 1986. Chemical weed control in commercial nursery and landscape plantings. MM-297. Ohio Coop. Ext. Serv., Ohio State Univ.
2. Smith, Elton M. 1983. Tolerance of canna to pre-emergence herbicides. Res. Rpt. No. Cent. Weed Ctr. Conf. 40:2,4
3. Smith, Elton M. 1980. Tolerance of summer flowering bulbs to pre-emergence herbicides. Res. Rpt. No. Cent. Weed Ctr. Conf. 37:8-9

An Evaluation of Cyanazine, Terbacil and Metolachlor Slow-Release Herbicide Tablets on Woody Landscape Crops

ELTON M. SMITH and SHARON A. TREASTER[1]

ABSTRACT

Slow-release herbicide tablets containing Cyanazine, Terbacil or metolachlor were evaluated on container grown *Cotoneaster dammeri* 'Royal Beauty', *Forsythia intermedia* 'Spring Glory' and *Rhododendron obtusum* 'Hershey Red.' Weed control with metolachlor was effective for 6-10 weeks from treatment depending on date while cyanazine and terbacil controlled weeds for 10 weeks. Metolachlor was not injurious to any of the test species while cyanazine was phytotoxic to cotoneaster. Cyanazine slightly injured Forsythia and Azalea. Terbacil was too toxic to the test plants to be considered for future use at the rates selected.

INTRODUCTION

Selected herbicides have been effective in slow release formulations in previous research (1,2,3,4,5,6) with container-grown nursery stock. The most satisfactory success has been in the control of annual grasses rather than broadleaf weeds. Most effective pre-emergence broadleaf herbicides such as diclobenil, oxadiazon and simazine do not have adequate solubility to leach from the tablets in rates high enough to control weeds.

Cyanazine, marketed as Bladex, is labelled for corn but not nursery crops. It is soluble and controls broadleaf weeds as well as grasses. Terbacil, sold as Sinbar, is registered for several agronomic and horticultural crops but not nursery stock. It, like Cyanazine, is readily soluble and controls a wide spectrum of grasses and broadleaf weeds.

The objective of this evaluation was to compare cyanazine and terbacil with metolachlor (Dual) in slow-release tablet formulation for weed control and phytotoxicity on three species of landscape crops. Dual is registered for nursery crops and has been successfully used in tablets previously by the authors (3,5).

MATERIALS AND METHODS

The herbicides evaluated were technical grade metolachlor (97.0 percent), cyanazine (90.0 percent) and terbacil (95.0 percent). Each herbicide was incorporated into the tablets at the rate of 10 and 20 Kg/ha. The tablets consisted of dicalcium phosphate and 2 percent magnesium stearate and were pressed with a Stokes Model F single-punch tablet machine.

Plant materials included were: *Cotoneaster dammeri* 'Royal Beauty' - Royal Beauty Cotoneaster, *Forsythia intermedia* 'Spring Glory' - Spring Glory Forsythia and *Rhododendron obtusum* 'Hershey Red' - Hershey Red Azalea. All plants were planted into 3.78 liter (1 gallon) containers in a pinebark-peat-sand medium (6-3-1 by volume). Plants were potted May 17, 1986 and fertilized with Osmocote 18-6-12 on May 20, 1986. The 12-gram herbicide tablets were applied one per container June 5, 1986. Plants were irrigated and maintained as for commercial conditions throughout the summer.

[1]Professor and Technician, Department of Horticulture, OSU

TABLE 1. Weed control and phytotoxicity from slow release tablets.

Herbicide Treatment	Rate Kg/ha	Date	Weed Control	Phytotoxicity Cotoneaster	Phytotoxicity Forsythia	Phytotoxicity Azalea
Control	—	June 19	9.0*	10.0*	10.0	10.0
Control	—	July 17	7.7	10.0	10.0	10.0
Control	—	Aug. 14	5.3	10.0	10.0	10.0
Metolachlor	10	June 19	9.0	10.0	10.0	10.0
Metolachlor	10	July 17	7.7	10.0	10.0	10.0
Metolachlor	10	Aug. 14	6.7	10.0	10.0	10.0
Metolachlor	20	June 19	9.0	10.0	10.0	10.0
Metolachlor	20	July 19	7.7	10.0	10.0	10.0
Metolachlor	20	Aug. 14	5.3	10.0	10.0	10.0
Cyanazine	10	June 19	9.0	9.3	10.0	10.0
Cyanazine	10	July 17	8.7	5.0	7.0	8.3
Cyanazine	10	Aug. 14	8.0	4.3	7.0	8.0
Cyanazine	20	June 19	9.3	10.0	10.0	10.0
Cyanazine	20	July 17	8.7	9.7	9.0	10.0
Cyanazine	20	Aug. 14	7.0	9.7	9.0	9.3
Terbacil	10	June 19	9.0	8.3	10.0	8.3
Terbacil	10	July 17	8.3	2.7	5.3	4.7
Terbacil	10	Aug. 14	7.0	1.7	5.0	3.7
Terbacil	20	June 19	9.3	9.3	10.0	10.0
Terbacil	20	July 17	8.0	3.7	6.0	5.0
Terbacil	20	Aug. 14	8.0	2.3	6.0	4.7

* Visual scale: 1-10 with 10 best and 7 or above acceptable.

There were three plants per species in each treatment with three replications of each treatment. Plants were arranged in a randomized block design. Evaluations were conducted at two, six and 10 week intervals from treatment. Weed control and phytotoxicity were rated on a 1-10 scale with 10 best and 7 or above acceptable.

RESULTS AND DISCUSSION

Weed control with metolachlor tablets at both 10 and 20 Kg/ha was effective for more than six weeks but less than 10 weeks as shown in Table 1. Cyanazine and terbacil at 10 and 20 Kg/ha effectively controlled weeds for 10 weeks, the duration of the study.

As anticipated, broadleaf weeds became invasive in the metolachlor plots especially spotted spurge, groundsel, and bittercress.

Metolachlor was completely non-injurious to cotoneaster, forsythia, and azalea at both rates (Table 1).

Cyanazine at the 10 Kg/Ra rate at the six and 10 week evaluation were much too phytotoxic to cotoneaster. There was some injury to both forsythia and azalea at the same evaluation dates, however, the injury was considered commercially acceptable.

Terbacil at both rates was severely phytotoxic to all three plant species at the six and 10 week evaluations.

Even though broadleaf weed control was satisfactory, terbacil cannot be applied to landscape crops in slow release form at the rates utilized in this study. However, cyanazine, although injurious to some degree on all three test species, should be investigated further at slightly lower rates and on a wider range of woody landscape crops since weed control is excellent.

LITERATURE CITED

1. Koncal, J.J., S.F. Gorske, and T.A. Fretz. 1981. Slow release herbicide formulation for weed control in container grown plants. Hort. Sci. 16(1):83-84
2. Ruizzo, M.A. 1982. Tablets: A Slow Release Herbicide Formulation. M.S. Thesis, The Ohio State Univ.
3. Ruizzo, M.A., E. M. Smith, and S. F. Gorske. 1983. Ohio Agri. Res.and Dev. Ctr. Res. Circ. 274, Ornamental Plants -1983: A Summary of Research, pp. 28-30.
4. Smith, A.E. and B.P. Verma. 1977. Weed control in nursery stock by controlled-release of alachlor. Weed. Sci., 25: 175-178
5. Smith, Elton M., Stanley F. Gorski and Melissa Moore. 1986. An evaluation of metribuzin slow release herbicide tablets on woody landscape crops. The Ohio State Univ.and Ohio Agr. Res. and Dev. Ctr., Res. Circ. 289, Ornamental Plants -1986: A Summary of Research, pp.14-17
6. Verma, B. P.and A. E. Smith,1978. Slow release herbicide tablets for container nursery. Trans. Amer. Soc. Agr. Eng. 21:1054-1059.

Tolerance of Landscape Vines to Selected Pre-Emergence Herbicides

ELTON M. SMITH and SHARON A. TREASTER[1]

ABSTRACT

The purpose of this evaluation was to determine the extent of phytotoxicity of Ronstar (oxadiazon), Surflan (oryzalin) and Devrinol (napropamide) on akebia, clematis, silver lace vine, trumpetcreeper and wisteria.

Devrinol at 4.0 and 8.0 lbs aia was completely nonphytotoxic to all 5 genera of vines. There was only slight phytotoxicity with Ronstar on clematis at the two and four week evaluation times. The clematis fully outgrew the injury by the sixth week. Surflan at the 2.0 lb aia rate slightly injured akebia through the first four weeks but there was no phytotoxicity at the 4.0 lb. aia (2X rate). There was also slight injury on silver lace vine at the 4.0 lb. aia rate after two weeks.

INTRODUCTION

With the expansion of crops being produced in containers in Ohio and nationally there is an increasing need for labeled herbicides for these crops. Presently there are no U.S. Environmental Protection Agency approved herbicides for use on woody landscape vines.

Previous research with Goal herbicides (1,2,3,4) has shown that it can be somewhat phytotoxic to landscape crops including landscape vines (5).

The specific objective of this study was to ascertain if three commonly used pre-emergence nursery herbicides (Devrinol, Ronstar and Surflan) could be applied to five woody landscape vines without phytotoxicity.

MATERIALS AND METHODS

Woody landscape vines in this study included: *Akebia quinata* - Common Akebia, *Campsis radicans* - Trumpetcreeper, *Polygonum aubertii* - Silver Lace Vine, and *Wisteria sinensis* - Chinese Wisteria.

Herbicides included in this study: 1) Devrinol 5G (napropamide) at 4.0 and 8.0 lb. aia, and 2) Ronstar 2G (oxadiazon) at 2.0 and 4.0 lb. aia.

The plants were grown in two or three gallon containers filled with a medium of pinebark-peat-sand (6-3-1) by volume. Plants were fertilized with Osmocote 18-6-12 at recommended rates for two and three gallon containers. Plants were irrigated as needed with overhead sprinklers.

[1]Professor and Technician, Dept. of Horticulture, OSU

TABLE 1. Vine Tolerance To Pre-Emergence Herbicides.

		Pre-Emergence Herbicide and Rate in Pounds						
		Ronstar		Surflan		Devrinol		Check
Vine Crop	Weeks from Treatment	3.0 aia	6.0 aia	2.0 aia	4.0 aia	4.0 aia	8.0 aia	—
Akebia quianta								
	2 weeks	10.0*	10.0	9.7	10.0	10.0	10.0	10.0
	4 weeks	10.0	10.0	9.3	10.0	10.0	10.0	10.0
	6 weeks	10.0	10.0	10.0	10.0	10.0	10.0	10.0
	8 weeks	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Campsis radicans								
	2 weeks	10.0	10.0	10.0	10.0	10.0	10.0	10.0
	4 weeks	10.0	10.0	10.0	10.0	10.0	10.0	10.0
	6 weeks	10.0	10.0	10.0	10.0	10.0	10.0	10.0
	8 weeks	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Clematis paniculata								
	2 weeks	9.7	8.7	10.0	10.0	10.0	10.0	10.0
	4 weeks	9.7	8.7	10.0	10.0	10.0	10.0	10.0
	6 weeks	10.0	10.0	10.0	10.0	10.0	10.0	10.0
	8 weeks	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Polygonum aubertii								
	2 weeks	10.0	10.0	10.0	9.0	10.0	10.0	10.0
	4 weeks	10.0	10.0	10.0	10.0	10.0	10.0	10.0
	6 weeks	10.0	10.0	10.0	10.0	10.0	10.0	10.0
	8 weeks	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Wisteria sinensis								
	2 weeks	9.7	9.0	10.0	10.0	10.0	10.0	10.0
	4 weeks	10.0	9.0	10.0	10.0	10.0	10.0	10.0
	6 weeks	10.0	10.0	10.0	10.0	10.0	10.0	10.0
	8 weeks	10.0	10.0	10.0	10.0	10.0	10.0	10.0

* Visual Scale: 1-10 with 1 = complete crop kill and 7 or above acceptable.

Herbicides were applied April 29, 1986 and plants were irrigated the day of application.

There were three plants per treatment with four replications placed in a randomized block design.

Phytotoxicity evaluations were on a 1-10 scale with 1 equal to complete death, 7 as acceptable and 10 equal to no phytotoxicity. Plants were evaluated May 13 (two weeks from treatment), May 27 (four weeks), June 10 (six weeks) and June 24 (eight weeks).

RESULTS AND DISCUSSION

Ronstar was completely non-phytotoxic to akebia, trumpet creeper, and silver lace vine. Slight foliage discoloration was observed on clematis and wisteria through four weeks but both species had outgrown the injury by the sixth week (Table 1).

Surflan was non-phytotoxic to trumpet creeper, clematis and wisteria. Only minor foliage injury was observed on akebia at the 2.0 lb. aia rate for four weeks and on silver lace vine at the 4.0 lb. aia rate for two weeks.

Devrinol was completely non-phytotoxic to all five genera of vines.

Trumpetcreeper was not injured by any of the herbicides in this study and was the most tolerant to Goal (oxyfluorfen) in 1985 research at The Ohio State University.

Akebia was injured by Surflan, clematis by Ronstar, silver lace vine by Surflan and wisteria by Ronstar. None of the phytotoxicity would result in commercially unacceptable plants since only lower foliage was discolored and all plants completely recovered. However, since some injury was observed on four of the five species selected, additional evaluations are warranted under varying environmental conditions with these and other pre-emergence herbicides.

In summary, there was no excessive phytotoxicity on akebia, clematis, silver lace vine, trumpet creeper or wisteria with either Ronstar, Surflan or Devrinol. Trumpetcreeper was the most tolerant species to all herbicides. Further research is suggested with pre-emergence herbicides on woody landscape vines to help obtain labelling by the US EPA for use by the nursery industry.

LITERATURE CITED

1. Smith, Elton M. 1981. Oxyfluorfen rate studies on container grown landscape crops. Research Report, North Central Weed Control Conf., 38:9-10.
2. Smith, Elton M. 1982. Rate studies of oxyfluorfen 1G on container grown landscape crops. Research Report, North Central Weed Control Conf., 39:2-3.
3. Smith, Elton M. and Sharon A. Treaster. 1985. Tolerance of azalea, cotoneaster and euonymus to Devrinol, Goal and Goal combinations. Ohio Agr. Res. and Dev. Ctr., Res. Circ. 284, Ornamental Plants -1985: A Summary of Research, pp-23-24.
4. Smith, Elton M. 1980. Tolerance of summer flowering bulbs to pre-emergence herbicides. Research Report, North Central Control Conf., 37:8-9.
5. Smith, Elton M. and Sharon A. Treaster. 1986. Tolerance of woody landscape vines to Goal combinations. Ohio Agri. Res. and Dev. Ctr. Res. Circ. 289, Ornamental Plants -1986: A Summary of Research, pp 9-11.

Influences of Supplementary High Intensity Discharge Lighting Upon the Growth of 'Ringo' Geranium and 'Scarletta' Begonia Plug Propagated Plants

JOHN C. PETERSON AND RICHARD P. VETANOVETZ[1, 2]

ABSTRACT

The effect of supplementary high intensity discharge lighting on the growth of 'Ringo' geraniums and 'Scarletta' begonias was examined. Six-week-old geranium and eight-week-old begonia plug sown seedlings were transplanted into 32 cell bedding plant flats on Feb. 19, Mar. 5, or Mar. 19. Transplants received 86 umole m^{-2} s^{-1} supplementary (0800 to 2400 hrs) HID lighting for two, four, six, or eight weeks following transplanting. Greenhouse conditions were 19°C night/21°C day, with 300-600 ppm supplementary CO_2. Plant height, fresh weight, and leaf area were recorded eight weeks after transplanting for all transplant dates. Supplementary HID lighting after transplant lasting four and two weeks after the first transplant date dramatically reduced production time for geraniums and begonias respectively. Time to salable size was reduced from six weeks to four weeks for geraniums and from 10 to six weeks for begonias. Lighting geraniums for more than four weeks or two weeks for begonias did not greatly enhance growth. The magnitude of growth differences between HID lighted plants and unlighted plants diminished with later transplant dates. Overall, begonias were more responsive to supplementary HID lighting than geraniums.

INTRODUCTION

Light can be a limiting factor for plant growth during low-light, winter months in northern greenhouses (10,13). This low-light period is generally identified as the time span between October and March (Table 1). During this time period many of the bedding plants are started (mid-January through mid-March) for traditional spring sales.

Bedding plant species such as begonias and geraniums can require up to 15 weeks to reach salable size. Therefore, growers usually begin production of these species by late January. Consequently, at least half of the production time for these crops takes place during periods of low-light. Cropping time is even greater when northern producers begin production of these crops at still earlier dates, for shipment to markets in southern states.

Research has shown that HID lighting can significantly enhance plant growth during winter months (1,6,7,9,13). Use of high intensity discharge (HID) lamps to supplement low light conditions offer bedding plant producers the opportunity to enhance plant quality as well as reduce crop production time and costs (6,9).

The use of plug sown bedding plant seedlings can also shorten cropping time subsequent to transplanting. This is achieved by avoiding plant stress associated with the conventional transplanting process and by transplanting when plants are at a more advanced physiological stage.

Some operations which produce plug sown bedding plants use HID lighting to enhance growth and quality of seedlings. It is not known, however, if additional HID lighting of these lighted plug sown seedlings would be beneficial after they are transplanted into the final containers.

The objective of this study was to assess the effect of continued HID lighting on the growth of two plug sown bedding plant crops, *Begonia x cultorum* 'Scarletta' and *Pelargonium x hortorum* 'Ringo' subsequent to transplanting.

TABLE 1. Total bi-weekly solar radiation levels and mean daily levels for each two week time period in Delaware, Ohio from December 25, 1981 through December 25, 1982.

	Solar Radiation (gram calories cm²)	
Time	Total	Daily mean
12-25 to 1-7	1469	104.9
1-8 to 1-21	2454	175.3
1-22 to 2-4	2040	145.7
2-5 to 2-18	2636	188.3
2-19 to 3-4	2813	200.9
3-5 to 3-18	3189	227.7
3-19 to 4-1	3872	276.6
4-2 to 4-15	5495	392.5
4-16 to 4-29	6617	472.6
4-30 to 5-13	7358	525.6
5-14 to 5-27	6417	458.4
5-28 to 6-10	5534	395.2
6-11 to 6-24	7054	503.8
6-25 to 7-8	5817	415.5
7-9 to 7-22	7367	526.2
7-23 to 8-5	7026	501.4
8-6 to 8-19	6657	475.5
8-20 to 9-2	4859	347.1
9-3 to 9-16	5248	374.8
9-17 to 9-30	3586	256.1
10-1 to 10-14	3713	265.2
10-15 to 10-28	3690	263.6
10-29 to 11-11	1841	131.5
11-12 to 11-25	1648	117.7

[1]Associate Professor and Graduate Research Associate respectively, Department of Horticulture.

[2]The authors wish to acknowledge Morrisons Greenhouses, Loveland, Ohio, and Country Acres Greenhouses, Marysville, Ohio, for the donation of lighting equipment and plant material.

MATERIALS AND METHODS

This study was conducted in two 6.4 x 14.6m double layer polyethylene (Monsanto 603) covered greenhouses. One greenhouse was equipped with ten-1000 watt high pressure sodium (HPS) lamps. These lamps supplemented natural light from 0800 to 2400 daily with 86 ± 10 umole $m^{-2} s^{-1}$ of photosynthetically active radiation (400-700 nm) as quantified with a Li-Cor model LI-185B light meter and LI-190SB quantum sensor. Minimum temperatures of 21°C day/17°C night were maintained and 300-600 ppm CO_2 supplemented during light hours.

Six-week-old 'Ringo' geranium and eight-week 'Scarletta' begonia plug sown seedlings were transplanted into 32 cell bedding plant flats containing Metro-Mix 360. These seedlings were grown in #406 plug flats (1 cell = 1.59 cm dia.) under 68 ± 5 umole $m^{-2} s^{-1}$ of high pressure sodium supplemental light from 1700 to 0200 hrs daily. Fifteen flats of each species were transplanted on February 19, March 5, and March 19, 1982. Initially, plants were watered in with a 400 ppm N (15-16-17) fertilizer solution. A 200 ppm N (15-16-17) fertilizer solution was applied at subsequent waterings. No growth regulators were applied.

Treatment groups included three flats of each variety which were lighted for zero, two, four, six, or eight weeks after transplanting. A completely randomized block design was utilized for placement of flats in the greenhouse. Flats were transferred from the lighted to the unlighted greenhouse at the end of the appropriate lighting treatment.

Plant height data was recorded periodically on five dates for the first transplant date treatment. A harvest date was identified for each treatment when begonia plants were 7 cm tall, the soil medium obscured by leaves, and 33 percent of the plants in flower. For geraniums, plants had to be 10 cm tall and the growing medium obscured by leaves. Plant height, leaf area, and fresh and dry weight, were recorded for all treatments eight weeks after each transplant date.

RESULTS

'Scarletta' Begonia

Begonia plants responded the most dramatically to supplemental HID lighting between the two species studied.

Begonia transplants lighted two or more weeks exhibited a dramatic increase in growth rate as evidenced by periodic height measurements (Figure 1). The enhanced growth rate resulted in a significant decrease in days to harvest as compared to unlighted plants (Table 2). Supplemental HID lighting for two weeks following transplanting decreased begonia production time 23, 15 and nine days, respectively, for the February 19, March 5 and March 19 transplant dates as compared to unlighted treatments. Lighting for four weeks or more reduced production time only three to five days more than two weeks of HID lighting following transplanting. Overall, the magnitude of growth differences among the unlighted

FIGURE 1. 'Scarletta' begonia height measurements taken periodically during production for the February 19 transplanting date lighting treatments.

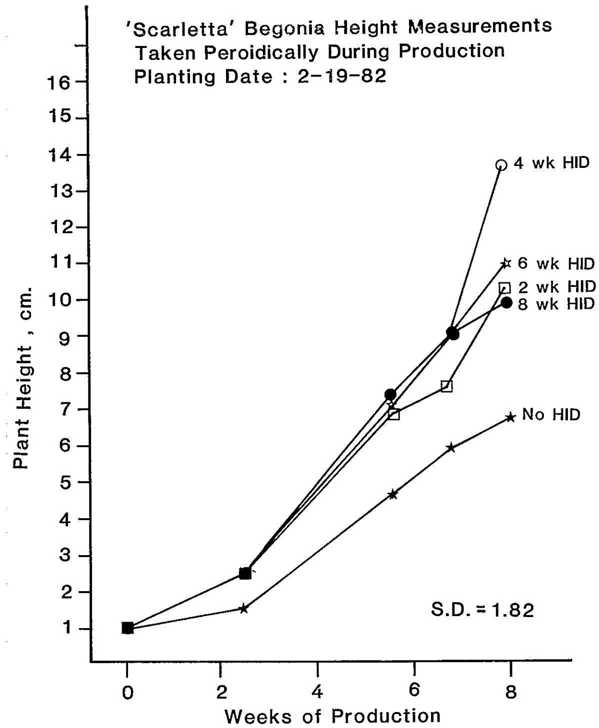


TABLE 2. Production time for 'Scarletta' begonia and 'Ringo' geranium plants transplanted on three dates and exposed to 0 to 8 weeks of supplementary HID lighting.

TRANSPLANT DATE	WKS. HID LIGHTING	DAYS TO HARVEST BEGONIA	GERANIUM
Feb. 19, 1982	0	66	41
	2	43	32
	4	40	26
	6	38*	28*
	8	38*	28*
Mar. 5, 1982	0	57	36
	2	42	34
	4	40	32
	6	39*	32*
	8	39*	32*
Mar. 19, 1982	0	53	34
	2	44	33
	4	41	34
	6	40*	36*
	8	40*	36*

*Plants reached saleable size prior to completion of lighting treatment.

plants and plants exposed to supplementary HID lighting diminished for later transplanting dates. Also, for unlighted treatment groups, the days to harvest decreased for later transplanting dates, from 66 days (February 19) to 57 days (March 5) to 53 days (March 19).

For the February 19 transplanting date plant height increased with up to four weeks of lighting and did not increase further if lighted six to eight weeks as compared to unlighted plants. Similarly, plant height increased with two and four weeks of HID lighting for the second (March 5) and third (March 19) transplanting dates, respectively. Additional weeks of lighting for each of these groups did not result in significantly greater plant height eight weeks after transplanting.

Dry weight of plant tops (Figure 3) and plant-leaf area (Figure 4) eight weeks after transplanting increased with increasing exposure to HID lighting. Among transplanting dates, dry weight decreased with later transplanting dates, but a similar pattern was not evident for leaf area measurements. The most apparent impact of supplementary HID lighting on leaf area resulted from only two weeks of lighting. Leaf-area values eight weeks after transplanting for plants exposed to two weeks of lighting were 19, 18, and 12 percent greater for the first, second and third transplanting dates, respectively, as compared to unlighted plants for the same transplanting dates.

FIGURE 3. Mean shoot dry weight of 'Scarletta' begonia plants 8 weeks after transplanting as affected by lighting treatments for each transplanting date.

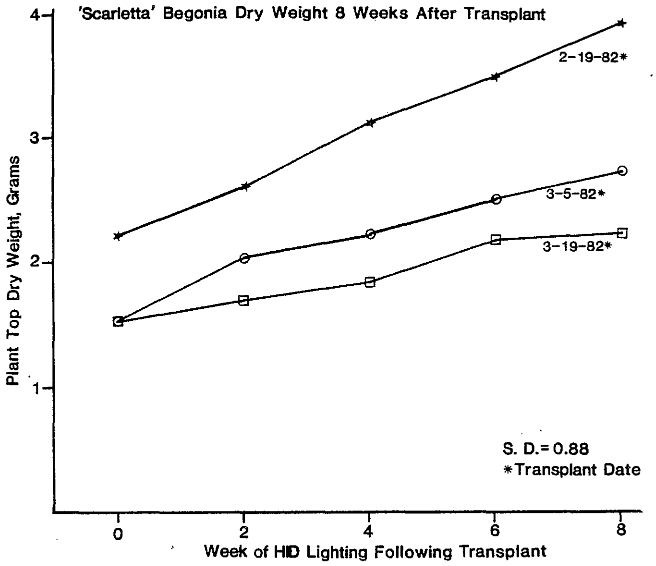


FIGURE 2. Mean plant height of 'Scarletta' begonia plants 8 weeks after transplanting as affected by lighting treatments for each transplanting date.

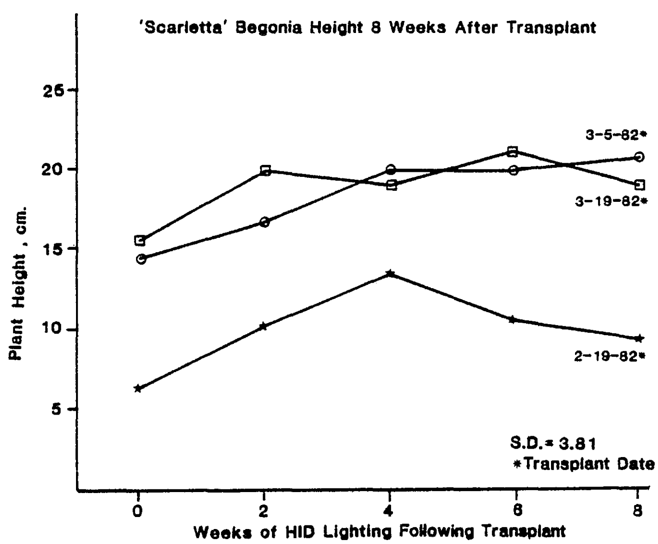
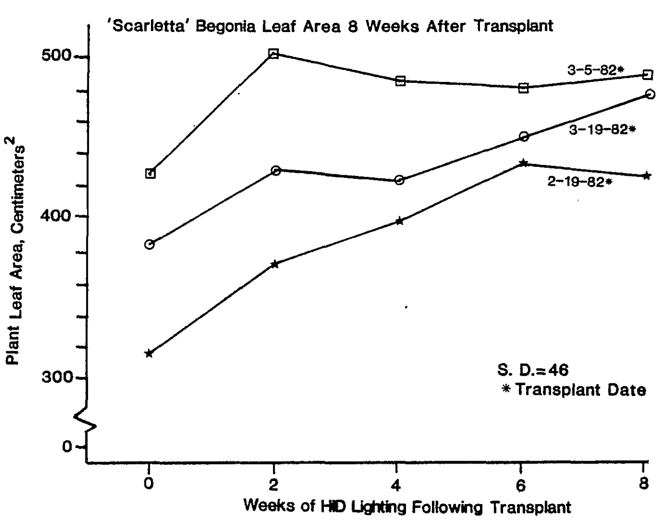


FIGURE 4. Mean leaf area of 'Scarletta' begonia plants eight weeks after transplanting as affected by lighting treatments for each transplanting date.



'Ringo' Geraniums

Geraniums were not as responsive as begonias to supplementary HID lighting. Substantial differences in production time (days to harvest) among plants grown under different lighting treatments were evident only for plants transplanted on February 19 (Table 2). Two and four weeks of supplementary HID lighting for first transplanting date plants decreased production time approximately 22 and 37 percent, respectively (Table 2). Additional weeks of HID lighting did not reduce production time. Among all treatments, four weeks of HID lighting following transplanting of geraniums on February 19 resulted in the shortest production time (26 days).

As with begonias, production time decreased for unlighted treatments with later transplanting dates. Exposure to supplementary HID lighting for the second transplanting date reduced days to harvest at most by four days. For the last transplanting date, lighting for two weeks reduced days to harvest by one day, four weeks of HID lighting had no effect, and six or eight weeks of HID lighting extended days to harvest by two days.

The greatest impact of HID lighting upon plant height was evident for the February 19 transplanting date (Figures 5 and 6). As with begonias, geranium height eight weeks after transplanting was increased with two or four weeks of HID lighting, and did not increase further with six or eight weeks of lighting as compared to unlighted plants. For the second transplanting date, height increased with up to six weeks of HID lighting. Plant height measurements for the third transplanting date increased slightly, with increasing exposure to HID lighting.

FIGURE 5. 'Ringo' geranium height measurements taken periodically during production for the February 19 transplanting date lighting treatments.

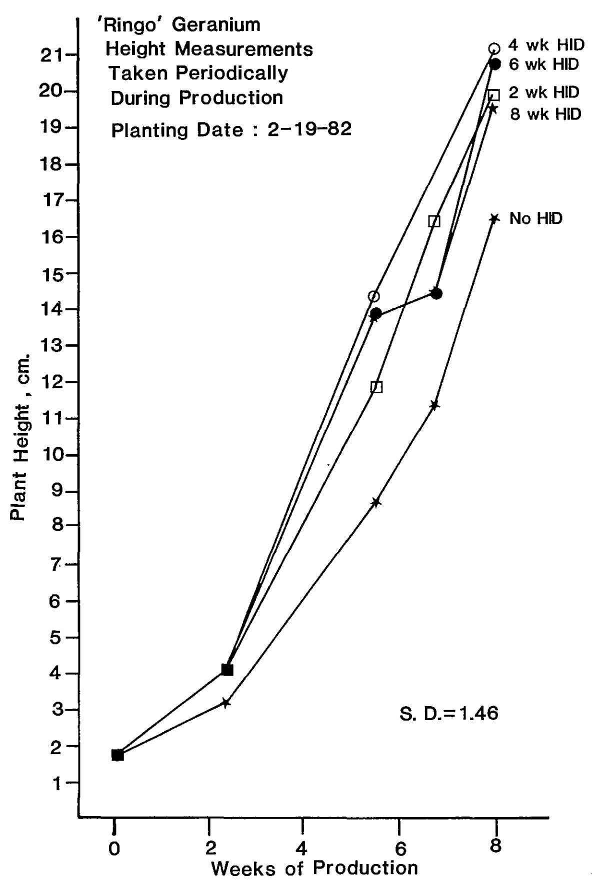
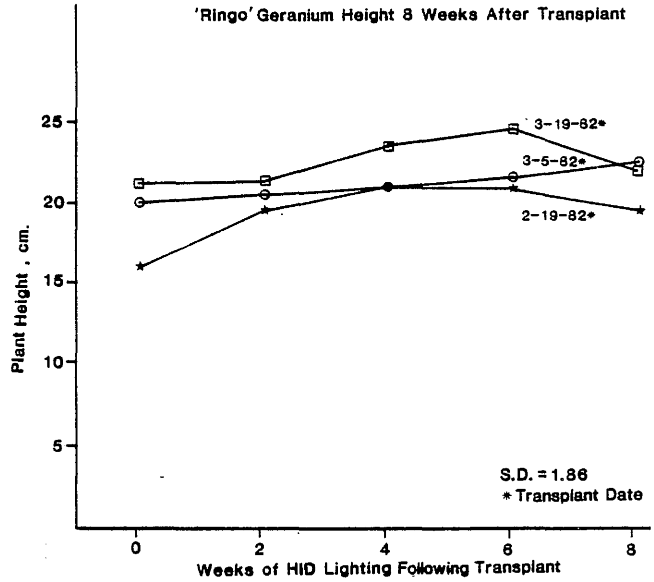


FIGURE 6. Mean plant height of 'Ringo' geranium plants 8 weeks after transplanting as affected by lighting treatments for each transplanting date.



Both dry weight of plant tops (Figure 7) and leaf area (Figure 8) increased with exposure to HID lighting. Dry weight values were generally lowest for plants transplanted on the earliest date. Plant leaf area values were the lowest for the last transplanting date.

DISCUSSION

In addition to the quantified data presented, the following observations were noted. Two or more weeks of supplemental HID lighting enhanced basal branching of begonias (Figure 9). It is believed that this response, to some extent, decreased days to harvest. One criterion for harvest date was that the growing medium be covered. Enhanced branching as a result of HID lighting has been previously reported (6,9).

Both begonias and geraniums exposed to HID lighting had darker green leaf color (Figures 10 and 11), the dark green color being enhanced with increasing exposure to HID lighting. Zonation of geranium leaves (Figure 11), a trait which is aesthetically desirable and normally not evident under natural light conditions was also enhanced. Enhanced color and zonation may have been a spectral response. Other causal factors may have been the carbon dioxide enrichment or an interaction between light and carbon dioxide (11).

FIGURE 7. Mean shoot dry weight of 'Ringo' geranium plants 8 weeks after transplanting as affected by lighting treatments for each transplanting date.

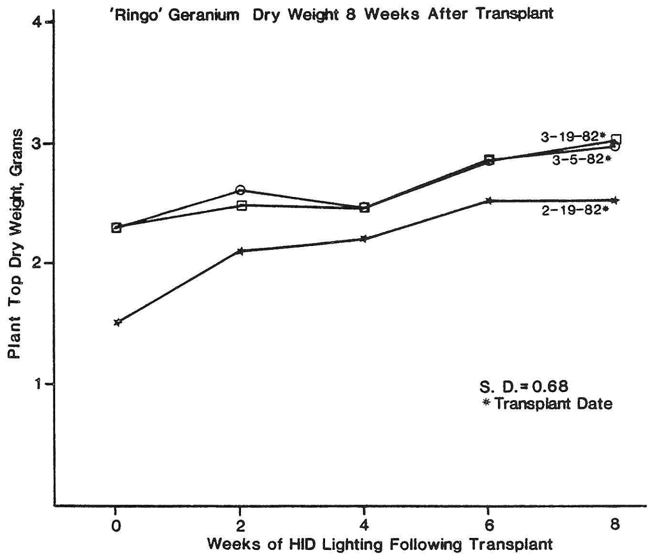
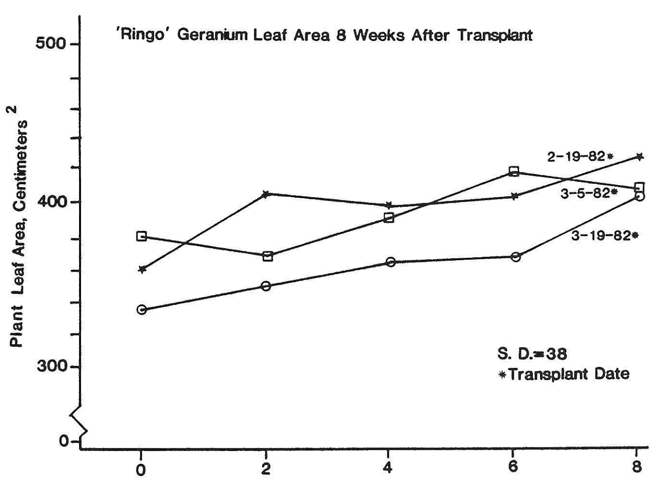


FIGURE 8. Mean leaf area of 'Ringo' geranium plants 8 weeks after transplanting as affected by lighting treatments for each transplanting date.



Flowering of begonias was hastened as was overall growth, but exposure to supplementary HID lighting did not appear to enhance the floriferousness of begonia plants. The growth retardant chlormequat was not applied to geranium plants, as might be done under commercial production situations (5). Consequently, the early flowering response triggered by an application of chlormequat (8) did not occur for plants in this study. In contrast to other reports, supplementary HID lighting did not appear to affect the flowering process of geranium plants during the duration of this study (2,3).

Data for plant height, plant top dry weight, plant leaf area, and days to harvest all reveal that the most dramatic growth response for begonia and geranium plants was achieved by exposure to two and four weeks, respectively, of supplementary HID lighting immediately following transplanting. Two factors relating to the lighting treatments are believed to have influenced the results obtained for begonia plants. These factors are photoperiod and intensity. Begonias are known to be responsive to long-day lighting (2,7). Extending the photoperiod with low intensity lighting has been found to accelerate the rate of growth of begonias, particularly in the seedling state. The increased light intensity provided by the supplementary HID lighting appears to have enhanced growth particularly during the first two weeks following transplanting. As evidenced by Figure 10, plants exposed to only two weeks of HID lighting following transplant displayed noticeable growth differences as compared to unlighted plants. The rapid establishment of seedlings after transplanting is believed to have enhanced subsequent growth. It is not clear whether the rapid establishment was totally attributable to photoperiod or light intensity.

Elevated light intensity, provided by the HID lights, appears to have been the primary factor leading to increased growth of geraniums for the first transplanting date. This view is supported by the fact that as natural light levels increased in later weeks of the year the effects of HID lighting upon growth were less evident. Furthermore, the growth rate of unlighted plants for the later transplanting dates was similar to lighted treatments for the earliest transplanting date.

The effects of carbon dioxide enrichment upon the results of this work are not clear since no plants were produced without supplementary carbon dioxide, but this factor should not be ignored. Carbon dioxide enrichment in combination with high intensity lighting has been shown to have a very dramatic influence upon plant growth (11).

Results indicate that for a commercial production situation two weeks and four weeks, respectively, of supplementary high pressure sodium HID lighting immdiately following transplanting of HID lighted plug grown seedlings under naturally low light conditions will dramatically reduce production times and enhance the quality of begonia and geranium crops.

The economic feasibility of this procedure would certainly have to be assessed in terms of light installation and operational costs as compared to reduced production time and enhanced product quality. Based on the short amount of time required to elicit a significant growth

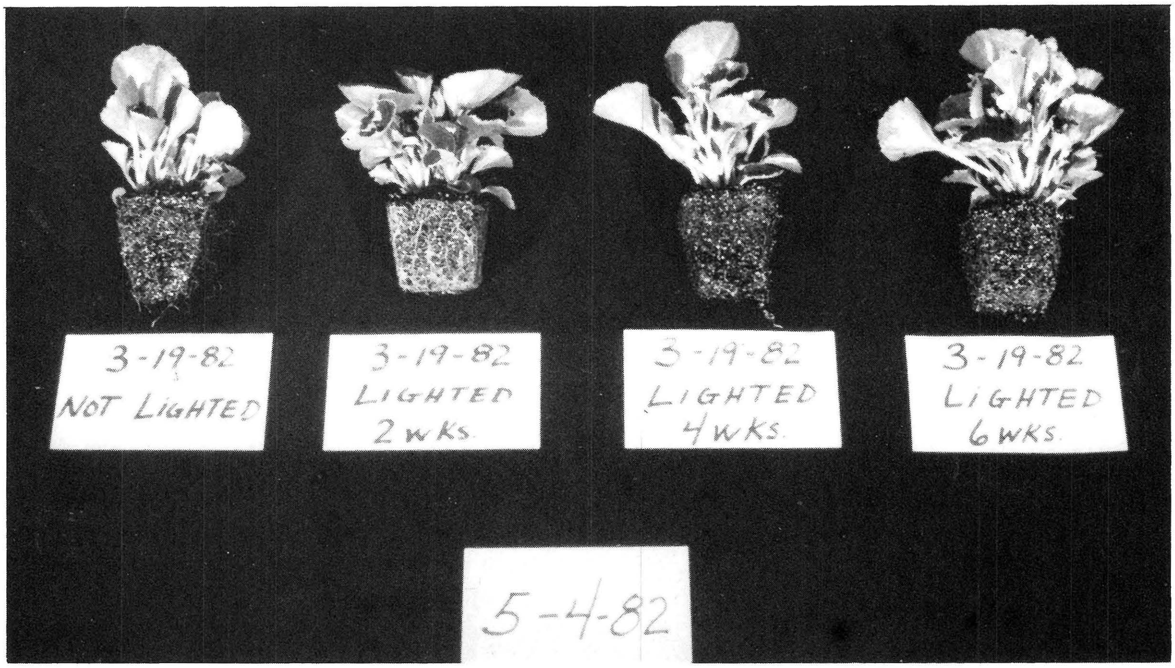


FIGURE 9. 'Scarletta' begonia plants exposed to 0, 2, 4, or 6 weeks of HID lighting following transplanting on 3-19-82. Picture taken 46 days after transplanting.

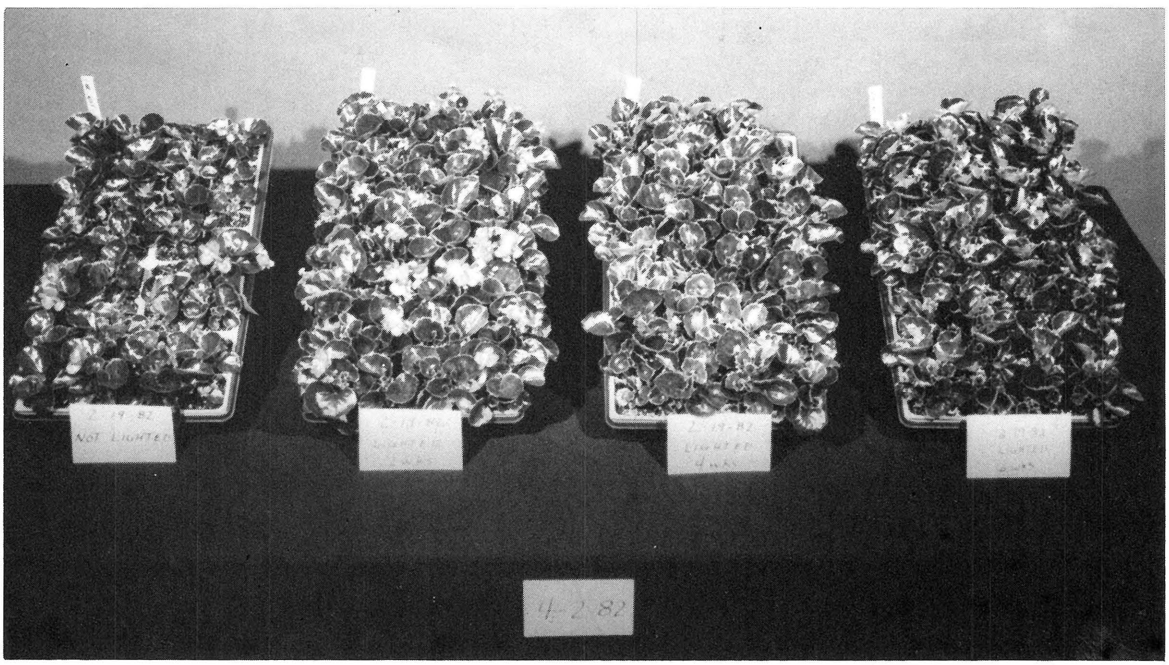


FIGURE 10. 'Scarletta' begonia plants exposed to 0, 2, 4, or 6 weeks of HID lighting following transplanting on 2-19-82. Picture was taken 36 days after transplanting.

Figure 11. 'Ringo' geranium plants exposed to 0, 2, or 4 weeks of HID lighting following transplanting on 2-19-82. Picture taken 28 days after transplanting.

response, it would appear that only a portion of a total production facility might need to be equipped with HID lighting. A production program might be developed which allows for the rotation of crops through a light treatment area.

Finally, this research involved only two of the many hundreds of bedding plant species and cultivars which are produced commercially. Future research should be conducted to evaluate the impact of supplementary HID lighting upon other bedding plants.

LITERATURE CITED

1. Armitage, A.M. 1981. Scheduling with light and temperature from the plants point of view. Ohio Flor. Assn. Bull. No. 621.
2. Armitage, A.M. and M.J. Tsujita. 1979. The effect supplemental light source, illumination and quantum flux density on the flowering of seed-propagated geraniums. Jour. of Hort. Sci. 54:195-198.
3. Armitage, A.M., M.J. Tsujita, and Patricia M. Harney. Effects of cycocel and high-intensity lighting on flowering of seed-propagated geraniums. Jour. of Hort. Sci. 53:147-149.
4. Bickford, E. D. and S. Dunn. 1972. Lighting for Plant Growth. Kent State Univ. Press. Kent, Ohio.
5. Brooks, W.M., H.K. Tayama, R.K. Lindquist, C.C. Powell, J.C. Peterson, W.R. Faber, J. Farley, and J.L. Robertson. 1981. Tips on growing bedding plants. MM-265. The Ohio State Univ. Columbus, Ohio.
6. Carpenter, W.J. 1974. High intensity lighting in the greenhouse. Res. Rpt. 255. Michigan State University., East Lansing, MI.
7. Carpenter, W.J. 1979. Environmental Factors: temperature, light, carbon dioxide. In Bedding Plants, John W. Mastalerz (ed.) Penn. Flower Growers, University Park, PA.
8. Carpenter, W.J. and W.H. Carlson. 1970. The influence of growth regulators and temperature on flowering of seed propagated geraniums. HortScience 5(3):183-184.
9. Cathey, H.M. and L.E. Campbell. 1979. Relative efficiency of high and low-pressure sodium and incadescent filament lamps used to supplement natural winter light in the greenhouse. J. Amer. Soc. Hort. Sci. 104(6):812-825.
10. Laurie, A., D.C. Kiplinger, and K.S. Nelson. 1979. Commercial Flower Forcing. McGraw-Hill, Inc. New York, N.Y.
11. Rogers, M.N. 1965. Night lighting hastens gloxinia vincas. Missouri St. Fl. News. 26(6):10-11.
12. Stinson, R.F. 1971. Environmental Factors: temperature light, carbon dioxide. In Geraniums, J. W. Mastalerz (ed.) Penn. Flower Growers, University Park, Pa.
13. Tsujita, M.J. 1978. High pressure lamps for Northern growers. Proceeding Eleventh International Bedding Plant Conference. Bedding Plants, Inc., East Lansing, MI.

Fixed Costs of Operating Field Nurseries in Ohio by Size of Firm and Species of Plant

BY REED D. TAYLOR, HAROLD H. KNEEN, ELTON M. SMITH, DAVID E. HAHN, AND STANLEY UCHIDA[1]

ABSTRACT

This study determined annual fixed costs (1985 dollars) of operating field nurseries in Ohio by size of firm and species of plant. In the 50-acre nursery analyzed, fixed costs per salable plant were $11.31 for *Taxus*, $8.08 for *Juniperus*, $7.56 for *Viburnum*, $25.09 for *Acer rubrum*, $17.16 for *Malus*, and averaged $11.29 for all plants. In the 200-acre nursery they were $4.90 for *Taxus*, $3.48 for *Juniperus*, $3.27 for *Viburnum* $10.87 for *Acer rubrum* $7.43 for *Malus*, and averaged $4.88 for all plants. The significant increase in asset utilization when going from the 50-acre to the 200-acre field nursery is due to the more efficient use of buildings, machinery, and equipment. Fixed costs as a percentage of total costs in the 50-acre nursery ranged from 46 to 65 percent, and averaged 55 percent for all species. Comparable values for the 200-acre nursery were 30 percent, 52 percent, and 39 percent.

INTRODUCTION

To make more informed decisions as to whether to enter, leave, or expand field production, nurserymen require production, marketing and financial information. In this paper, fixed costs for production of crops representing five categories of field-grown production schemes and two sizes of nurseries in USDA Plant Hardiness Zones Five and Six were developed.

Nurserymen throughout the United States have been gradually shifting from field to container production for many species of plants (15). Large companies and many individual nurserymen who traditionally produce field-grown stock have diversified operations by shifting part of their production to container-grown plants. Containers allow greater flexibility in production and marketing and at least in some cases, are less expensive than field production (15). But, risk is reduced when plans are grown in the field. Field-grown plants have greater buffering against variations in moisture, nutrients, and temperature. When subjected to conditions that would kill or severely damage container-grown plants with no overwintering protection, field-grown plants will often survive with little damage. It is also easier to "hold-over" field-grown plants when market conditions are not favorable. Field production continues to provide the majority of plants grown for the landscape market. However, changes and competition in the industry make it imperative that nurserymen continually and systematically determine their costs.

Production cost models have recently been developed for several species of plants in the southern and north central regions of the U.S.(1,2,3,4,5,6,7,9,10,11,12,13 14,15,16). While providing excellent information for individual species, these models do not contain all the features of a complete nursery operation. Taylor et al. developed a comprehensive model applicable to Plant Hardiness Zone 6 for container-grown crops representing five categories of container-grown production schemes and two sizes of nurseries (15). Badenhop and Phillips (2) developed a similiar study for field-grown crops in USDA Plant Hardiness Zones 7 and 8 representing five categories of fieldgrown production schemes and two sizes of nurseries. Procedures and data developed by the two earlier comprehensive studies have proven useful and complementary to this study.

MATERIALS AND METHODS

Two model firms were synthesized using the conceptual framework of economic engineering wherein the "best proven practice" was included in each model. They were synthesized based on conditions observed in the vicinity of Columbus, Ohio. The complete model included developing an appropriate production cycle; schematic drawings of the physical layout, including buildings and irrigation system; lists of equipment and other items; a complete sequence by month and year of nursery operational steps beginning with land preparation and ending with loading the finished product for wholesale distribution and budgets for fixed and variable costs (15).

Data were obtained from wholesale nurseries and nursery suppliers in Ohio during the late autumn and winter of 1984 and the spring of 1985. Price quotations obtained were for the 1985 production season. The basic goal in synthesizing the production facilities were to minimize labor expenses, flow and movement of plant material and equipment, maximize the number of salable plants, and allow future expansion.

The model small nursery was 50 acres with 40 acres of growing space and 10 acres of production facilities, holding area, field bed area and roads. The large nursery was 200 acres with 175 acres of growing space and 25 acres of production facilities, holding area, field bed area, and roads. Initial analysis for the 50-acre nursery showed that basic equipment needed for a modern 50-acre field nursery could support a much larger operation. It was

[1]Associate Professor, and former Graduate Student, Dept. of Agricultural Economics and Rural Sociology; Professor, Dept. of Horticulture; Professor, and former Graduate Student , Dept. of Agricultural Economics and Rural Sociology. Mr. Kneen is currently Director of Marketing, Studebaker Nurseries, Inc. , New Carlisle, Ohio. Mr. Uchida works for BANCOHIO, Columbus, Ohio.

In addition to research, Drs. Taylor, Smith, and Hahn have appointments in the Ohio Cooperative Extension Service.

found that it would take a nursery of at least 200 acres to use modern facilities and equipment in an economically efficient manner.

We assumed that the two model nurseries would produce a diverse line of nursery stock and that the length of the production cycle for the different species grown vary. Commonly grown nursery stock were divided into five cultural groups. While not all inclusive, the groups do permit calculating a range of per unit costs related to input costs and cultural factors. For analytical purposes, we assumed that each cultural group would occupy 20 percent of the nursery area (i.e., 50-acre nursery = 8 acres production plus 2 acres facility per group; 200-acre nursery = 35 acres production plus 5 acres facility per group). Annual sales capacity for the 50-acre nursery would be 20,759 plants and for the 200-acre nursery, 90,867 plants. For detailed analysis, one specific plant from each group was chosen as representative of the group. While it is recognized that other plants from each category would have somewhat different requirements, it was felt that the requirements would not vary significantly in cost from the representative plant. The five groups with some of their cultural characteristics are listed below:

Group	Plant	Cultural Characteristics
I.	**SLOW-GROWING EVERGREENS**	
	Taxus (species) *Buxus* (species)	18-24" salable plant 12" B&B 10.2 sq. ft. per plant
II.	**RAPID-GROWING EVERGREENS**	
	Juniperus *chinensis* (varieties) *horizontalis* (varieties) *Pinus strobus* *Thuja* (species)	18-24" salable plant 12" B&B 10.2 sq. ft. per plant
III.	**DECIDUOUS SHRUBS**	
	Viburnum (species) *Forsythia* (species) *Weigela* (species) *Ligustrum* (species)	3-4' salable plant 12" B&B 11.9 sq. ft. per plant
IV.	**SHADE TREES**	
	Acer rubrum (varieties) *Acer platanoides* (varieties) *Quercus* (species) *Fraxinus* (species) *Tilia* (species) *Gleditsia* (species)	2" caliper 24" B&B 33.6 sq. ft. per plant
V.	**ORNAMENTAL TREES**	
	Malus (flowering crab) (species) *Prunus* (Ornamental plums) (species)	5-6' (1 1/2 - 1 3/4" caliper) 20" B&B 28.7 sq. ft. per plant

Costs were established for all factors of production including management and invested capital. In economic terms, costs associated with factors of production supplied by owner/operators are often referred to as 'opportunity costs' or the income these factors could have received if they were employed elsewhere. For example, owners could usually be employed as managers at other nurseries, and money invested in land, buildings, irrigation systems, and equipment could have earned interest if it had been placed in financial institutions.

Most nurseries use cash rather than accrual accounting procedures. For this reason, the analyses were completed on a "cash" basis. This approach does not give a true economic picture of the cost of producing a plant since it does not take into account the time value of money from the time the plant is planted until it is harvested. The analyses do, however, give a reliable estimate of the annual cost per salable plant. Another problem with cash accounting is taking into account the start-up period (i.e., the period from when costs are first incurred until plants are ready for sale). This paper did not attempt to assess costs or alternative actions for this period.

Based upon capital requirements for establishing Ohio field nurseries as previously reported (12,15), annual fixed costs were determined (Tables 3 and 3a). Annual fixed costs per cultural group were then determined by dividing total fixed costs by five (Tables 4 and 4a). Based on these figures, fixed costs per saleable plant were calculated (Tables 5 and 5a). These analyses allowed cost comparisons based on cultural practices and size of nursery. See Taylor et al. (15) for details on specific fixed costs. Annual variable and total costs of producing three of the five cultural groups of plants are reported in companion articles in this publication (pages 37 to 56).

RESULTS AND DISCUSSION

Annual fixed costs associated with capital, including depreciation, interest, and taxes, were $124,868 per year for the 50-acre nursery. In addition there was $102,960 allocated for general overhead and $6,678 for interest on general overhead, insurance and taxes. Thus fixed costs for the 50-acre nursery totalled $234,506 (Table 3). These costs were divided by five and assigned to the respective production areas of the five plant groups with each group

TABLE 1. Plant Densities and Losses for Field Production of Nursery Plants in Ohio, 1985.

Group	Description	Size of Salable Plant	Years in Rotation	Spacing Between Rows	Spacing in Rows	Sq Ft per Plant*	Plants per Acre	Estimated Percent Loss†
I	Slow-growing Evergreens—*Taxus*	18-24″	7	44″	28″	10.2	4,272	15
II	Fast-growing Evergreens—*Juniperus*	18-24″	5	44″	28″	10.2	4,272	15
III	Deciduous Shrubs—*Viburnum*	3-4′	4	48″	30″	11.9	3,652	15
IV	Shade Trees—*Acer rubrum*	2″ diameter	5	96″	42″	33.6	1,298	10
V	Ornamental Trees—*Malus*	5-6′ (1-1/2″)	4	96″	36″	28.7	1,518	10

*Sq ft per plant includes necessary perimeter roads.

†Assume one-half of loss between first and second year and remainder in last year of production. Losses in the last year of production would be left in the field.

TABLE 2. Plant and Harvesting Requirements for a 50-Acre* Field Nursey in Ohio, 1985.

Plant Group	Description	Propagation† Units Stuck	Bedding Area‡ Rooted Cuttings Planted	Field Planting Acres	Field Planting Acres Planted per Year	Field Planting Units Planted per Year	Field Planting Units Harvested** per Year
I	Slow-growing Evergreens—*Taxus*	7,914	6,088	8	1.14	4,870	4,140
II	Fast-growing Evergreens—*Juniperus*	11,107	8,544	8	1.60	6,835	5,810
III	Deciduous Shrubs—*Viburnum*	11,869	9,130	8	2.00	7,304	6,208
IV	Shade Trees—*Acer rubrum*††	--	--	8	1.60	2,076	1,869
V	Ornamental Trees—*Malus*††	--	--	8	2.00	3,036	2,732
	TOTAL	30,890	23,762	40	8.34	24,121	20,759

*Total of 50 acres, with 40 acres in field growing space and 10 acres in production facilities, holding area, field bed area, roads, etc.

†For each plant available for transplanting as a rooted cutting into the bedding area, it is estimated that 1.3 cuttings would need to be stuck in the propagation facility.

‡For each plant available for transplanting into the field, it is estimated that 1.25 rooted cuttings would need to be planted in the bedding area.

**Assume one-half dug in the fall for fall sales and overwintering and one-half dug in the spring.

††Shade and ornamental trees would be purchased as bare-root liners for planting directly into the field.

TABLE 2a. Planting and Harvesting Requirements for a 200-Acre* Field Nursey in Ohio, 1985.

Plant Group	Description	Propagation† Units Stuck	Bedding Area‡ Rooted Cuttings Planted	Field Planting Acres	Field Planting Acres Planted per Year	Field Planting Units Planted per Year	Field Planting Units Harvested** per Year
I	Slow-growing Evergreens—*Taxus*	37,710	26,700	35	5.00	21,360	18,156
II	Fast-growing Evergreens—*Juniperus*	48,594	37,380	35	7.00	29,904	25,418
III	Deciduous Shrubs—*Viburnum*	51,927	39,944	35	8.75	31,955	27,162
IV	Shade Trees—*Acer rubrum*††	--	--	35	7.00	9,086	8,177
V	Ornamental Trees—*Malus*††	--	--	35	8.75	13,283	11,954
	TOTAL	138,231	104,024	175	36.50	105,588	90,867

*Total of 200 acres, with 175 acres in field growing space and 25 acres in production facilities, holding area, field bed area, roads, etc.
†For each plant available for transplanting as a rooted cutting into the bedding area, it is estimated that 1.3 cuttings would need to be stuck in the propagation facility.
‡For each plant available for transplanting into the field, it is estimated that 1.25 rooted cuttings would need to be planted in the bedding area.
**Assume one-half dug in the fall for fall sales and overwintering and one-half dug in the spring.
††Shade and ornamental trees would be purchased as bare-root liners for planting directly into the field.

TABLE 3. Annual Fixed Costs (Dollars) for 50-Acre* Field Nursery in Ohio, 1985.

Item	Description	Depreciation†	Interest‡	Insurance and Taxes**	Total
Land	Unimproved land	--	12,000	2,000	14,000
+Improvements	Grading, tiling, graveling, pond	5,182	13,819	2,303	21,304
Subtotal		5,182	25,819	4,303	35,304
Buildings					
Office and restrooms	20′ x 40′	1,260	3,360	685	5,305
Plant and supply storage	40′ x 50′	1,800	4,800	978	7,578
Machinery storage and shop	40′ x 50′	1,800	4,800	978	7,578
Polyhouse structures (5 ea)	200′ x 20′	1,242	1,657	338	3,237
Subtotal		6,102	14,617	2,979	23,698
Machinery and Equipment					
Tractor, 100 hp	100 hp, diesel fuel	2,545	3,393	107	6,045
Tractor, 34 hp (2 ea)	34 hp, gas fuel	2,611	3,481	110	6,202
Articulated 4-wheel drive loader	Swinger 320—lift capacity = 3,000 lb.	3,420	4,560	144	8,124
Tree spade	530P handles 20″, 22″, and 24″ + lift pads	3,821	1,019	32	4,872
Forks	For front-end loaders	99	132	4	235
Plow	3-14″ plows	235	314	10	559
Disk	8′ wide	351	468	15	834
Harrow	10′ wide	59	78	2	139
Cultimulcher—bed area	10′ wide	342	456	14	812
Sprayrig (boom sprayer)	100-gallon tank with 10′ boom	181	169	5	355
Transplanter, 3-row	3-20″ row bed transplanter	675	900	28	1,603
Transplanter, 1-row	Tree planter	450	600	19	1,069
Permanent irrigation/well pump	100 hp electric pump	1,638	4,368	138	6,144
In-ground irrigation/bed area	PVC pipe/valves	498	1,328	42	1,868
Above-ground irrigation/bed area	Aluminum pipe/valves/sprinkler heads	329	220	7	556
In-ground irrigation storage/holding	PVC pipe/valves	311	829	26	1,166
Above-ground irrigation storage/holding	Aluminum pipe/valves/sprinkler heads	433	289	9	731
Traveler gun—field irrigation	450-500 gallons per minute	1,980	2,640	83	4,703
Portable irrigation pump	40 hp P.T.O irrigation pump/foot valve	38	51	2	91

*Total of 50 acres, with 40 acres in growing space and 10 acres in production facilities, holding area, field bed area, roads, etc.
†Depreciation was estimated by dividing initial cost (adjusted for a 10% salvage value) by the years of useful life.
‡Interest costs were estimated by multiplying the initial value of land, buildings, equipment, and machinery by the interest rate, 12% per annum.
**Insurance and taxes.
Land and improvements—only taxes are assessed, at a rate of $20 per $1,000 of market value.
Buildings—taxes assessed at a rate of $20 per $1,000 of market value. Insurance, $500 deductible, at $4.46 per $1,000 of market value. Total for category = $24.46 per $1,000.
Machinery and equipment—taxes are not assessed in Ohio on personal property. Insurance, $500 deductible, at $3.78 per $1,000 of initial value.
††Less than $0.50.
‡‡Insurance for personnel was estimated at 32% of salaries for owner/operator, supervisor, and clerical.
***Owner/operator = $30,000, supervisor = $20,000, clerical = $10,000, supplies 10% or $6,000. Total = $66,000.

TABLE 3 (continued). Annual Fixed Costs (Dollars) for a 50-Acre* Field Nursery in Ohio, 1985.

Item	Description	Depreciation†	Interest‡	Insurance and Taxes**	Total
Machinery and Equipment (continued)					
Airblast sprayer	300 gallon high pressure on trailer	463	432	14	909
Fertilizer injector (2 ea)	26-gallon injector—bed use	309	206	6	521
Transplanter, 2-row	2-42″ row field transplanter	504	672	21	1,197
U-Blade—field	18″ for undercutting	43	29	1	73
Undercutter—bed	Bed undercutter, 50″ blade, lift tines	37	34	1	72
Fertilizer sidedresser	2-row sidedresser	90	120	4	214
Cultivator, 2-row	2-row field cultivator	219	204	6	429
Wagons (4 ea)	4-wheel, farm wagon	712	949	30	1,691
Cultivator, 3-row	3-row bed cultivator	289	270	9	568
Truck	1/2 ton pickup truck	2,427	1,618	51	4,096
Pallets (181 ea)	Wooden	977	261	8	1,246
Hand tools (20 sets)	Miscellaneous	360	240	8	608
Seeder	Broadcast seeder	16	21	1	38
Mower	7′—3-blade mower	205	274	9	488
Flatbed truck (1/2 unit)	24′ flatbed, gas fuel	3,780	2,520	79	6,379
Heating system for propagation					
Gas-fired unit heater—Modine	200,000 BTU (input)	99	132	4	235
Fan jet	Acme	10	12	††	22
Thermostat	Two-stage	4	5	††	9
Set-up for propane	Ventilator, regulator, etc.	9	12	††	21
Set-up for heating system	Plywood, braces, bolts, etc.	9	12	††	21
Other propagation materials					
Misting systems (3 ea)	Mist-a-matic	336	90	3	429
Pipe and nozzles	For misting systems	135	36	1	172
Treated boards	5/4″ x 8″ x variable length	110	29	1	140
Heating cable		141	38	1	180
Subtotal		31,300	33,511	1,055	65,866
Total for Depreciation, Interest, Insurance, and Taxes		42,584	73,947	8,337	124,868
General Overhead					
Utilities	Telephone, electric, gas heat				6,200
Licenses and bonds					400
General repairs and maintenance	Buildings, grounds, roads				7,060
Advertising and printing					1,200
Insurance, personnel‡‡	Workmen's compensation, FICA, health, unemployment				19,200
Travel and professional fees					1,900
Administrative and management***	Clerical, operator, supervisory, labor, and office supplies				66,000
Miscellaneous					1,000
Subtotal					102,960
Interest on General Overhead, Insurance and Taxes	12% per annum for 6 months on a total of $111,297				6,678
Total Annual Fixed Costs					234,506

*Total of 50 acres, with 40 acres in growing space and 10 acres in production facilities, holding area, field bed area, roads, etc.
†Depreciation was estimated by dividing initial cost (adjusted for a 10% salvage value) by the years of useful life.
‡Interest costs were estimated by multiplying the initial value of land, buildings, equipment, and machinery by the interest rate, 12% per annum.
**Insurance and taxes.
Land and improvements—only taxes are assessed, at a rate of $20 per $1,000 of market value.
Buildings—taxes assessed at a rate of $20 per $1,000 of market value. Insurance, $500 deductible, at $4.46 per $1,000 of market value. Total for category = $24.46 per $1,000.
Machinery and equipment—taxes are not assessed in Ohio on personal property. Insurance, $500 deductible, at $3.78 per $1,000 of initial value.
††Less than $0.50.
‡‡Insurance for personnel was estimated at 32% of salaries for owner/operator, supervisor, and clerical.
***Owner/operator = $30,000, supervisor = $20,000, clerical = $10,000, supplies 10% or $6,000. Total = $66,000.

TABLE 3a. Annual Fixed Costs (Dollars) for 200-Acre* Field Nursery in Ohio, 1985.

Item	Description	Depreciation†	Interest‡	Insurance and Taxes**	Total
Land	Unimproved land	- -	48,000	8,000	56,000
+Improvements	Grading, tiling, graveling, pond	12,789	34,105	5,684	52,578
Subtotal		12,789	82,105	13,684	108,578
Buildings					
Office and restrooms	20′ x 40′	1,260	3,360	685	5,305
Plant and supply storage	40′ x 50′	1,800	4,800	978	7,578
Machinery storage and shop	40′ x 50′	1,800	4,800	978	7,578
Polyhouse structures (21 ea)	200′ x 20′	5,218	6,958	1,418	13,594
Subtotal		10,078	19,918	4,059	34,055
Machinery and Equipment					
Tractor, 100 hp	100 hp, diesel fuel	2,545	3,393	107	6,045
Tractor, 60 hp	60 hp, diesel fuel	1,838	2,450	77	4,365
Tractor, 34 hp (4 ea)	34 hp, gas fuel	5,221	6,962	219	12,402
Articulated 4-wheel drive loader (2 ea)	Swinger 220—lift capacity = 2,000 lb.	4,500	6,000	189	10,689
Articulated 4-wheel drive loader (2 ea)	Swinger 320—lift capacity = 3,000 lb	6,840	9,120	287	16,247
Tree spade (2 ea)	530P handles 20″, 22″, and 24″ + lift pads	7,641	2,038	64	9,743
Forks	For front-end loaders	396	528	17	941
Plow	3-14″ plows	235	314	10	559
Disk	8′ wide	351	468	15	834
Harrow	10′ wide	59	78	2	139
Cultimulcher—bed area	10′ wide	342	456	14	812
Sprayrig (boom sprayer)	100-gallon tank with 10′ boom	181	169	5	355
Transplanter, 3-row	3-20″ row bed transplanter	675	900	28	1,603
Transplanter, 1-row	Tree planter	450	600	19	1,069
Permanent irrigation/well pump	100 hp electric pump	1,638	4,367	138	6,143
In-ground irrigation/bed area	PVC pipe/valves	1,557	4,153	131	5,841
Above-ground irrigation/bed area	Aluminum pipe/valves/sprinkler heads	782	522	16	1,320
In-ground irrigation storage/holding	PVC pipe/valves	808	2,155	68	3,031
Above-ground irrigation storage/holding	Aluminum pipe/valves/sprinkler heads	1,491	994	31	2,516
Traveler gun—field irrigation	450-500 gallons per minute	1,980	2,640	83	4,703
Portable irrigation pump	40 hp P.T.O irrigation pump/foot valve	38	51	2	91
Airblast sprayer	300 gallon high pressure on trailer	463	432	14	909
Fertilizer injector (2 ea)	26-gallon injector	307	205	6	518
Transplanter, 2-row	2-42″ row field transplanter	504	672	21	1,197
U-Blade—field	18″ for undercutting	43	29	1	73
Undercutter—bed	Bed undercutter, 50″ blade, lift tines	37	34	1	72
Fertilizer sidedresser	2-row sidedresser	90	120	4	214
Cultivator, 2-row (2 ea)	2-row field cultivator	450	420	13	883
Wagons (8 ea)	4-wheel, farm wagon	1,424	1,899	60	3,383
Cultivator, 3-row	3-row bed cultivator	289	270	9	568
Truck (2 ea)	1/2 ton pickup truck	4,855	3,236	102	8,193
Pallets (482 ea)	Wooden	2,603	694	22	3,319
Hand tools (76 sets)	Miscellaneous	1,368	912	29	2,309
Seeder	Broadcast seeder	16	21	1	38
Mower	7′—3-blade mower	205	274	9	488
Flatbed truck**	24′ flatbed, gas fuel	7,560	5,040	159	12,759
Heating system for propagation					
Gas-fired unit heaters (2 ea)	200,000 BTU (input)	199	265	8	472
Fan jet (2 ea)	Acme	19	24	1	44
Thermostat (2 ea)	Two-stage	8	11	††	19
Set-up for propane (2 ea)	Ventilator, regulator, etc.	18	24	1	43
Set-up for heating system (2 ea)	Plywood, braces, bolts, etc.	18	24	1	43

*Total of 200 acres, with 175 acres of growing space and 25 acres in production facilities, holding area, field bed area, roads, etc.
†Depreciation was estimated by dividing initial cost (adjusted for a 10% salvage value) by the years of useful life.
‡Interest costs were estimated by multiplying the initial value of land, buildings, equipment, and machinery by the interest rate, 12% per annum.
**Insurance and taxes.
Land and improvements—only taxes are assessed, at a rate of $20 per $1,000 of market value.
Buildings—taxes assessed at a rate of $20 per $1,000 of market value. Insurance, $500 deductible, at $4.46 per $1,000 of market value. Total for category = $24.46 per $1,000.
Machinery and equipment—taxes are not assessed in Ohio on personal property. Insurance, $500 deductible, at $3.78 per $1,000 of initial value.
††Less than $0.50.
‡‡Insurance for personnel was estimated at 32% of salaries for owner/operator, supervisor, and clerical.
***Owner/operator = $35,000, two supervisors @ $20,000 each = $40,000, two clerical @ $10,000 each = $20,000, supplies 10% or $9,500. Total = $104,500.

TABLE 3a (continued). Annual Fixed Costs (Dollars) for a 200-Acre* Field Nursery in Ohio, 1985.

Item	Description	Depreciation†	Interest‡	Insurance and Taxes**	Total
Machinery and Equipment (continued)					
Other propagation materials					
Misting systems (6 ea)	Mist-a-matic	672	179	6	857
Pipe and nozzles	For misting systems	270	72	2	344
Treated boards	5/4" x 8" x variable length	440	117	4	561
Heating cable		567	151	5	723
Subtotal		61,993	63,483	2,001	127,477
Total for Depreciation, Interest, Insurance, and Taxes		84,860	165,506	19,744	270,110
General Overhead					
Utilities	Telephone, electric, gas heat				9,200
Licenses and bonds					600
General repairs and maintenance	Buildings, grounds, roads				12,200
Advertising and printing					1,800
Insurance, personnel‡‡	Workmen's compensation, FICA, health, unemployment				30,400
Travel and professional fees					2,725
Administrative and management***	Clerical, operator, supervisory, labor, and office supplies				104,500
Miscellaneous					2,000
Subtotal					163,425
Interest on General Overhead, Insurance and Taxes	12% per annum for 6 months on a total of $183,169				10,990
Total Annual Fixed Costs					444,525

*Total of 200 acres, with 175 acres of growing space and 25 acres in production facilities, holding area, field bed area, roads, etc.
†Depreciation was estimated by dividing initial cost (adjusted for a 10% salvage value) by the years of useful life.
‡Interest costs were estimated by multiplying the initial value of land, buildings, equipment, and machinery by the interest rate, 12% per annum.
**Insurance and taxes.
Land and improvements—only taxes are assessed, at a rate of $20 per $1,000 of market value.
Buildings—taxes assessed at a rate of $20 per $1,000 of market value. Insurance, $500 deductible, at $4.46 per $1,000 of market value. Total for category = $24.46 per $1,000.
Machinery and equipment—taxes are not assessed in Ohio on personal property. Insurance, $500 deductible, at $3.78 per $1,000 of initial value.
††Less than $0.50.
‡‡Insurance for personnel was estimated at 32% of salaries for owner/operator, supervisors, and clerical.
***Owner/operator = $35,000, two supervisors @ $20,000 each = $40,000, two clerical @ $10,000 each = $20,000, supplies 10% or $9,500. Total = $104,500.

TABLE 4. Summary of Annual Fixed Costs (Dollars) of Operating a 50-Acre* Field Nursery in Ohio, 1985.

Item	Group I (*Taxus*)	Group II (*Juniperus*)	Group III (*Viburnum*)	Group IV (*Acer rubrum*)	Group V (*Malus*)	Total
Fixed Costs						
Land and improvements	7,061	7,061	7,061	7,061	7,061	35,304†
Buildings	4,740	4,740	4,740	4,740	4,740	23,698†
Machinery and equipment	13,173	13,173	13,173	13,173	13,173	65,866†
General overhead	20,592	20,592	20,592	20,592	20,592	102,960†
Interest on general overhead, insurance, and taxes	1,336	1,336	1,336	1,336	1,336	6,678†
Subtotal	46,902	46,902	46,902	46,902	46,902	234,506†
Salable Plants Per Year	4,140	5,810	6,208	1,869	2,732	20,759
Annual Fixed Costs per Salable Plant	11.31	8.08	7.56	25.09	17.16	11.29

*Total nursery = 50 acres, with 40 acres of growing space and 10 acres in production facilities, holding and field bed area, roads, etc.
†Individual figures do not always add to the total due to rounding.

TABLE 4a. Summary of Annual Fixed Costs (Dollars) of Operating a 200-Acre* Field Nursery in Ohio, 1985.

Item	Group I (*Taxus*)	Group II (*Juniperus*)	Group III (*Viburnum*)	Group IV (*Acer rubrum*)	Group V (*Malus*)	Total
Fixed Costs						
Land and improvements	21,716	21,716	21,716	21,716	21,716	108,578†
Buildings	6,811	6,811	6,811	6,811	6,811	34,055†
Machinery and equipment	25,495	25,495	25,495	25,495	25,495	127,477†
General overhead	32,685	32,685	32,685	32,685	32,685	163,425†
Interest on general overhead, insurance, and taxes	2,198	2,198	2,198	2,198	2,198	10,990†
Subtotal	88,905	88,905	88,905	88,905	88,905	444,525†
Salable Plants Per Year	18,156	25,418	27,162	8,177	11,954	90,867
Annual Fixed Costs per Salable Plant	4.90	3.48	3.27	10.87	7.43	4.88

*Total nursery = 200 acres, with 175 acres of growing space and 25 acres in production facilities, holding and field bed area, roads, etc.
†Individual figures do not always add to the total due to rounding.
‡Tree liners were purchased rather than propagated. Liner costs were included under materials.

TABLE 5. Summary of Fixed, Variable, and Total Costs (Dollars) per Salable Plant of Operating a 50-Acre* Field Nursery in Ohio, 1985.

Item	Group I (*Taxus*)		Group II (*Juniperus*)		Group III (*Viburnum*)		Group IV (*Acer rubrum*)		Group V (*Malus*)		Average	
	Cost per Salable Plant	Percent of Total Cost	Cost per Salable Plant	Percent of Total Cost	Cost per Salable Plant	Percent of Total Cost	Cost per Salable Plant	Percent of Total Cost	Cost per Salable Plant	Percent of Total Cost	Cost per Salable Plant	Percent of Total Cost
Fixed Cost Items												
Land and Improvements	1.70	(10)	1.22	(10)	1.14	(9)	3.78	(7)	2.58	(7)	1.70	(8)
Buildings	1.14	(7)	0.82	(7)	0.76	(6)	2.54	(5)	1.73	(5)	1.14	(6)
Machinery and Equipment	3.18	(18)	2.27	(18)	2.12	(18)	7.05	(13)	4.82	(13)	3.17	(16)
General Overhead	4.97	(28)	3.54	(28)	3.32	(28)	11.01	(20)	7.54	(20)	4.96	(24)
Interest on General Overhead, Insurance, and Taxes	0.32	(2)	0.23	(2)	0.22	(2)	0.71	(1)	0.49	(1)	0.32	(1)
Subtotal	11.31	(65)	8.08	(65)	7.56	(63)	25.09	(46)	17.16	(46)	11.29	(55)
Variable Cost Items												
Propagation	0.66	(4)	0.27	(2)	0.26	(3)	†		†		0.29	(1)
Materials	0.98	(5)	0.75	(6)	0.76	(6)	16.56	(30)	10.05	(28)	3.45	(17)
Machinery and Equipment	1.42	(8)	1.03	(8)	0.96	(8)	5.30	(10)	3.39	(9)	1.78	(9)
Labor	2.75	(16)	2.13	(17)	2.21	(18)	5.97	(11)	5.10	(14)	3.02	(15)
Interest on Operating Capital	0.35	(2)	0.25	(2)	0.25	(2)	0.67	(3)	1.11	(3)	0.51	(3)
Subtotal	6.16	(35)	4.43	(35)	4.44	(37)	29.50	(58)	19.65	(54)	9.05	(45)
Total Costs per Salable Plant	17.47	(100)	12.51	(100)	12.00	(100)	54.58	(100)	36.82	(100)	20.34	(100)

*Total nursery = 50 acres, with 40 acres of growing space and 10 acres in production facilities, holding and field bed area, roads, etc.
†Tree liners were purchased rather than propagated. Liner costs were included under materials.

TABLE 5a. Summary of Fixed, Variable, and Total Costs (Dollars) per Salable Plant of Operating a 200-Acre* Field Nursery in Ohio, 1985.

Item	Group I (Taxus) Cost per Salable Plant	Group I (Taxus) Percent of Total Cost	Group II (Juniperus) Cost per Salable Plant	Group II (Juniperus) Percent of Total Cost	Group III (Viburnum) Cost per Salable Plant	Group III (Viburnum) Percent of Total Cost	Group IV (Acer rubrum) Cost per Salable Plant	Group IV (Acer rubrum) Percent of Total Cost	Group V (Malus) Cost per Salable Plant	Group V (Malus) Percent of Total Cost	Average Cost per Salable Plant	Average Percent of Total Cost
Fixed Cost Items												
Land and Improvements	1.20	(13)	0.85	(12)	0.80	(11)	2.66	(7)	1.82	(7)	1.19	(10)
Buildings	0.38	(4)	0.27	(4)	0.25	(4)	0.83	(2)	0.57	(2)	0.37	(3)
Machinery and Equipment	1.40	(15)	1.00	(14)	0.94	(13)	3.11	(9)	2.13	(9)	1.40	(11)
General Overhead	1.80	(19)	1.28	(18)	1.20	(17)	4.00	(11)	2.73	(11)	1.80	(14)
Interest on General Overhead, Insurance, and Taxes	0.12	(1)	0.08	(1)	0.08	(1)	0.27	(1)	0.18	(1)	0.12	(1)
Subtotal	4.90	(52)	3.48	(49)	3.27	(46)	10.87	(30)	7.43	(30)	4.88	(39)
Variable Cost Items												
Propagation	0.20	(2)	0.11	(1)	0.10	(1)	†		†		0.10	(1)
Materials	0.94	(10)	0.77	(11)	0.77	(11)	13.88	(39)	9.02	(37)	3.07	(25)
Machinery and Equipment	0.65	(7)	0.47	(7)	0.52	(8)	3.03	(9)	2.51	(10)	1.02	(8)
Labor	2.45	(26)	2.05	(29)	2.19	(31)	6.43	(18)	4.79	(19)	2.93	(24)
Interest on Operating Capital	0.25	(3)	0.21	(3)	0.22	(3)	1.40	(4)	0.98	(4)	0.43	(3)
Subtotal	4.49	(48)	3.61	(51)	3.80	(54)	24.74	(70)	17.30	(70)	7.55	(61)
Total Costs per Salable Plant	9.39	(100)	7.09	(100)	7.07	(100)	35.61	(100)	24.73	(100)	12.43	(100)

*Total nursery = 200 acres, with 175 acres of growing space and 25 acres in production facilities, holding and field bed area, roads, etc.
†Tree liners were purchased rather than propagated. Liner costs were included under materials.

receiving an assessment of $46,902 (Table 4). It was felt that the most reasonable way of assigning annual fixed costs initially was by area. Once the physical facility is provided, fixed costs are incurred at essentially the same amount regardless of how the nursery facility is used.

On a per-salable-plant basis there was a considerable difference in annual fixed costs among plant groups (Table 5). In the 50-acre nursery, they were: $11.31 for Group I (Taxus), $8.08 for Group II (Juniperus), $7.56 for Group III (Viburnum), $25.09 for Group IV (Acer rubrum), and $17.16 for Group V (Malus). The average over all groups was $11.29. Fixed costs for Group IV plants were more than three times as much as for Group III. These costs were proportional to the number of salable plants per annum produced in the allocated space. Fixed costs as a percentage of total costs ranged from 46 to 65 percent in the 50-acre nursery and averaged 55 percent for the five groups (Table 5).

For the 200-acre nursery, annual fixed costs associated with capital investment (depreciation, interest, insurance, and taxes) were $270,110. An additional $163,425 was allocated for general overhead and $10,990 for interest on general overhead, insurance, and taxes making a total of $444,525 annual fixed costs for the 200-acre nursery (Table 3a). Assessment per plant group was $88,905 (Table 4a). Fixed costs per-salable-plant were: $4.90 for Group I, $3.48 for Group II, $3.27 for Group III, $10.87 for Group IV, and $7.43 for Group V, and averaged $4.88 for all groups (Table 5a). Fixed costs as a percent of total costs were considerably lower than for the 50-acre nursery, ranging from 30 to 52 percent and averaged 39 percent for all groups (Table 5a). This lower percenta ge was associated with the lower capital requirement persalable plant capacity.

Fixed costs per salable plant were substantially lower for the 200-acre nursery compared to the 50-acre nursery. For Group I the difference was $6.41, for Group II $4.60, for Group III $4.29, for Group IV $14.22, and for Group V $9.73, and averaged $6.41 for all groups. This more than doubling in efficiency when going from the 50-acre to the 200-acre nursery is once again attributable to better utilization of buildings, machinery, and equipment of the large nursery compared to the small.

While many nurserymen and others concerned with the industry might feel that the reported fixed cost figures ranging from 30 to 65 percent of total costs depending upon size of firm and species of plant might be high, these percentages are in line with those for similar industries with new facilities.

Brumfield et. al. (8) in a synthesized analysis of overhead costs of greenhouse firms found fixed (overhead) costs as a percent of sales to range from about 45 percent to over 67 percent depending on size of firm and market channel. The cost estimates of this study are not directly comparable with Brumfield et. al. (percent of total costs versus percent of sales). However, if marketing costs and potential profit were taken into account so that a direct comparison could be made, the fixed costs from the Brumfield study, as a percent of total costs, would be similiar to those reported here. Recent studies on nurseries, however, did show lower fixed costs as a percentage of total costs.

Badenhop and Phillips (2), for USDA Plant Hardiness Zones 7 and 8, showed fixed costs ranging from 37 to 48 percent of total costs in a 50-acre nursery and from 27 to 36 percent in a 100-acre nursery. Most of the difference between the two studies could be accounted for by differences in budgeting. Bandenhop and Phillips did not provide for irrigation or drainage, two very expensive procedures provided for in this study. They also allocated less for nursery overhead. Finally, they used different procedures for computing interest on investment. In computing interest on depreciable items, the calculations by Badenhop and Phillips were based on one-half the original value of depreciable items to reflect the recovery of those items through depreciation. In this study, interest was computed on the total cost of depreciable items.

Taylor et. al. (15) in a study of container operations in USDA Plant Hardiness Zone 6 found fixed (overhead) costs as a percent of total costs to range from 37 to 51 percent depending on size of firm and number of salable plants. Analytical procedures in the Taylor et. al. study were identical to this study. The major difference is in the assumption about the number of salable plants produced per year. In the container study, a nursery containing approximately eight acres of growing space would produce about 95,650 salable plants per year, and a nursery containing approximately 16 acres of growing space would produce about 192,095 salable plants per year. Therefore, fixed (overhead) costs were distributed over many more plants. Also capital requirements per salable plant capacity were much lower in the container nurseries. For the eight-acre (growing space) nursery, they ranged from \$4.63 to \$9.09 capital requirement per salable plant capacity. In the 16-acre (growing space) nursery, they ranged from \$3.71 to \$7.39. As reported earlier, capital requirements per salable plant in this study ranged from \$10.16 to \$65.94 depending upon species of plant and size of field nursery (15).

One of the major reasons for the large difference in capital requirements per salable plant capacity lies in the plant rotations. The container nursery operated on a two-year rotation while the rotations for this field study range from four years in the case of Group III (*Viburnum*) and Group V plants (*Malus*) to seven years in the case of Group I (*Taxus*) plants.

Nurserymen having established facilities might calculate annual fixed costs to be lower than those reported here. This is especially true if they calculate depreciation and repairs on the original value of land improvements, buildings, machinery, and equipment and if they place a low value on their own management input. Good management for planning purposes, however, dictates computing depreciation and repairs on the current value of facilities and equipment rather than on original cost. It also dictates placing a value on managerial time that would be comparable to salaries paid in competitive firms.

IMPLICATIONS

Fixed costs per salable plant in the 50-acre nursery ranged from \$7.56 to \$25.09 and averaged \$11.29. In the 200-acre nursery comparable costs were \$3.27 to \$10.87 and averaged \$4.88. The greater than 100 percent gain in efficiency when going from the 50 to 200 acre nursery is attributable to more efficient use of buildings, machin ery, and equipment. Fixed costs as a percentage of total costs in the 50-acre nursery ranged from 46 to 65 percent and averaged 55 percent for all species. Comparable values for the 200-acre nursery were 30 to 52 percent, and averaged 39 percent. Differences in fixed costs among plants resulted from a combination of space requirements and the number of years a plant would be in rotation.

A comparison of total costs of producing "balled-and-burlapped" plants in a 50-acre nursery in the field in USDA Plant Hardiness Zones 5 and 6 with prices in producers' wholesale catalogs would undoubtedly show selling prices lower than total annual costs. In fact, a comparison of costs with prices for the 200-acre field nursery would also, at best, show marginal returns. In fact, if one were to add the costs of selling to production costs, very few producers would presently be charging enough to cover all costs, let alone earn profits. How then can producers continue to operate? The answer lies in how producers both experience and compute costs. We have used the economic and accounting method which includes both explicit and implicit costs. Explicit costs are paid directly and are easily determined, e.g., cost of liners, soil media, polyethylene, chemicals, and labor. Implicit costs are those that are more difficult to determine, such as the cost of equity capital and implied managerial salaries. The way these costs are determined varies significantly from firm to firm. Well-established nurseries are usually very accurate in determining explicit costs, but often do not consider all implicit costs. They base their costs on "cash flow" and profit and loss on "tax accounting." These established nurseries may have purchased land at low cost, be working with depreciated equipment, and may be assigning low if any value to their management. In this case, calculated costs would be at a much lower level than presented in this paper. Also, as pointed out earlier, careful site selection could significantly reduce fixed (overhead) costs. However, if one were to start a new field nursery, in a "normal" USDA Plant Hardiness Zone 5 or 6 site, costs would probably be very close to those presented here.

For the industry, selling nursery products below "accounting costs" implies that well-established nurseries, operating essentially debt free, would have strong staying power whereas those who have just started or are heavily in debt may not be able to survive, especially if they are relying on their field operation to meet all over head expenses. Second, starting a field nursery (unless it were quite large) in USDA Plant Hardiness Zones 5 and 6 would probably not prove profitable unless items like buildings, equipment, machinery, management, etc., could be shared with other enterprises or unless selling prices of nursery products in the zones increased substantially. At current prices for nursery products, this study shows that the return on investment for establishing new, independently operating, field nurseries in USDA Plant Hardiness Zones 5 and 6 would be marginal if not negative.

LITERATURE CITED

1. Aylsworth, James and J.B. Gartner. 1972. The Seven Costs of Ornamental Production. Amer. Nurseryman, 135: (2):116-122.
2. Badenhop, M.B., and T.D. Phillips and S-103 Technical Committee. 1986. Costs of Establishing and Operating Field Nurseries Differentiated by Size of Firm and Species of Plant in USDA Climatic Zones 7 and 8. Southern Coop. Ser. Bull. 311.
3. Badenhop, M.B., and T.D. Phillips and S-103 Technical Committee. 1983. Cost of Producing and Marketing Container-Grown Woody Landscape Plants:The Pfitzer Juniper. Southern Coop. Ser. Bull. 299.
4. Badenhop, M.B., A.E. Einert and S-103 Technical Committee. 1980. Factors Affecting Production Costs and Returns for Flowering Dogwood. Southern Coop. Ser. Bull. 246.
5. Badenhop, M.B., Robert D. Wright and S-103 Technical Committee. 1980. Cost of Producing and Marketing a Shade Tree: The Pin Oak. Southern Coop. Ser. Bull. 244.
6. Badenhop, M.B., and S-103 Technical Committee. 1979. Factors Affecting Southern Regional Production Advantages for Kurume Azaleas. Southern Coop. Ser. Bull. 241.
7. Badenhop, M.B., and S-103 Technical Committee. 1979. Factors Affecting Southern Regional Production Advantages for *Juniperus chinensis* 'Pfitzeriana'. Southern Coop. Ser. Bull. 237.
8. Brumfield, Robin G., Robin G., Paul V. Nelson, Arthur J. Coutu, Daniel W. Willets and Robert S. Sowell. 1981. Overhead Costs of Greenhouse Firms by Size of Firm and Market Channel. North Carolina Agr Res Ser Tech. Bul. 269.
9. Coutu, A.J. and S-103 Technical Committee. 1982. Nursery Management and Production Cost: Burford Holly *Ilex Cornuta* 'Burfordii'. Southern Coop. Ser. Bull. 274.
10. Crafton, Vicky W., Travis D. Phillips, and Thomas M. Blessington. 1982. Costs of Producing Woody Ornamental Plants. Agr. Econ. Res. Rep. 137, Mississippi Agr. and For. Exp. Sta.
11. Dickerson, H.L., M.B. Badenhop and J.W. Day. 1983. Cost of Producing and Marketing Rooted Cuttings of Three Woody Ornamental Species in Tennessee, 1980. Tennessee Agr. Exp. Sta. Bull. 624.
12. Kneen, Harold H., Reed D. Taylor, Elton M. Smith, David E. Hahn, and Stanley Uchida. 1986. Physical Facilities and Capital Requirements for Establishing a 200-Acre Field Nursery in Ohio—1985. Ohio Agri. Res. and Dev. Ctr., Res. Circ. 289, Ornamental Plants—1986: A Summary of Research, pp. 31-39.
13. Kneen, Harold H. 1981. Comparison of Costs for Producing Containerized and Field Grown *Juniperus chinensis* 'Pfitzeriana' in USDA Climatic Zones 6 and 7. M.S. Thesis, The Ohio State Univ., Columbus.
14. Powers, Edward W. 1978. An Analysis of Production Costs for Containerized Nursery Products. M.S. Thesis, The Ohio State Univ., Columbus.
15. Taylor, Reed D., Harold H. Kneen, Elton M. Smith, David E. Hahn, Stanley Uchida, and S-103 Technical Committee. 1985. Costs of Establishing and Operating Field Nurseries Differentiated by Size of Firm and Species of Plant in USDA Climatic Hardiness Zones Five and Six. Southern Coop. Ser. Bull. 315.
16. Taylor, Reed D., Harold H. Kneen, David E. Hahn, Elton M. Smith and S-103 Technical Committee. 1983. Costs of Establishing and Operating Container Nurseries Differentiated by Species of Plant in U.S.D.A. Climatic Zone Six. Southern Coop. Ser. Bull. 301.

Costs of Producing Slow-Growing Evergreens (*Taxus*) in the Field by Size of Firm in Ohio

HAROLD H. KNEEN, REED D. TAYLOR, ELTON M. SMITH, DAVID E. HAHN AND STANLEY UCHIDA[1]

ABSTRACT

This study was designed to determine annual production costs for field-grown slow-growing evergreens in Ohio by size of firm. This objective was accomplished by synthesizing two model field nurseries using the conceptual framework of economic engineering. Once the nurseries were synthesized, growing space was divided into five equal parts with each part being assigned a plant group. In the 50-acre nursery, slow-growing evergreens were allocated eight acres of growing space and in the 200-acre nursery 35 acres. One specific species of slow-growing evergreen (*Taxus*) was chosen for detailed analysis.

In the space allocated, 4,140 salable *Taxus*, of size 18-24 inches, could be produced annually in the 50-acre nursery and 18,156 in the 200-acre nursery Total costs per salable plant were $17.47 in the 50-acre nursery and $9.39 in the 200-acre nursery. These costs were based on 1985 figures.

INTRODUCTION

Slow-growing evergreens, such as the various species of *Buxus* and *Taxus*, have long been planted for hedges, foundation plantings, and other locations where low maintenance is desirable. These plants have traditionally been grown in the field. However, new technological developments are now making it economically feasible to grow them in containers. Container production allows greater flexibility in production and marketing, and in most cases, is less expensive than field production. On the other hand, growing plants in the field reduces risks. Field-grown plants have greater buffering against variations in moisture, nutrients, and temperature. When subjected to conditions that would kill or severely damage container-grown plants with no overwintering protection, field-grown plants will often survive with little damage. It is also easier to "hold-over" field-grown plants when market conditions are not favorable. This is especially true with slow-growing evergreens. It is anticipated that the majority of slow-growing evergreens will continue to be produced in the field for the foreseeable future, especially in the case of the larger plants.

[1]Former Graduate Student, and Associate Professor, Dept. of Agricultural Economics and Rural Sociology, Professor, Dept. of Horticulture, Professor, and former Graduate Student, Dept. of Agricultural Economics and Rural Sociology. Mr. Kneen is currently Director of Marketing, Studebaker Nurseries, Inc., New Carlisle, Ohio. Mr. Uchida works for BANCOHIO, Columbus, Ohio.

In addition to research, Drs. Taylor, Smith, and Hahn have appointments in the Ohio Cooperative Extension Service.

MATERIAL AND METHODS

In the study, two model firms were synthesized using the conceptual framework of economic engineering where in the 'best proven practice' was included in each model. They were synthesized based on conditions observed in the vicinity of Columbus, Ohio. The complete synthesis included developing an appropriate production cycle; schematic drawings of the physical layout, including buildings and irrigation systems; lists of equipment and other items; a complete sequence by month and year of nursery operational steps beginning with propagation and ending with loading the finished product for wholesale distribution; and budgets for fixed and variable costs.

Data for this study were obtained in 1985 from wholesale nurseries and nursery suppliers in Ohio. The basic goals in synthesizing the production facilities were to minimize labor expenses, flow and movement of plant material and equipment, water runoff, and initial investment, as well as to maximize the number of salable plants and keep future expansion possible. See Taylor et al. (1) for a detailed analysis of the physical plant, production system, and capital production budgets.

The first step in the production cycle consisted of collecting cuttings from field plants that were at least three years old. Cuttings were trimmed and treated with a hormone solution and stuck in a heated sand bed in an "overwintering" house. During March of the third production year, the 18-month-old rooted cuttings are pulled from the propagation beds, root pruned by hand, and planted seven inches within rows, 20 inches apart between rows, in four-feet-wide beds. After three years in the beds, they were dug, root and top pruned by hand, and planted in the field. Approximately 25 percent of the field-grown crop is harvested and sold during the fall of the sixth field production year and another 25 percent dug, overwintered, and sold during late winter and early spring of the seventh field production year. The remaining 50 percent of the crop was harvested and sold during late winter and spring of the seventh field production year. After the harvest is complete, the land is left fallow and disked for weed control four times during summer months. The fields were plowed in the fall of the seventh production year in preparation for spring planting.

A model facility was synthesized for both a 50-acre and a 200-acre field nursery. The nursery operations were assumed to produce a diverse line of nursery stock, each having its own unique production cycle. Commonly grown nursery stock was divided into five cultural groups. While not all inclusive, the groups do permit developing a range of per unit costs related to input costs and cultural factors. For analytical purposes, it was assumed that each cultural group would occupy 20 percent of the field growing area (i.e., 50-acre nursery = 8 acres per group, 200-acre nursery = 35 acres per group). In addition to the field growing area, the 50-acre nursery had 10 acres and the 200-acre nursery 25 acres of production facilities including overwintering houses, propagation facilities, shipping area, holding area, liner bed area, pond, supply shed, machinery storage, machine shop, office, and rest rooms. Costs developed on slow-growing evergreens (*Taxus*) therefore were based on the scale of complete nurseries, but were analyzed on the basis of percent of total space occupied. Companion studies in this publication report on fixed costs (page 26), costs for deciduous shrubs (page 45), and costs for shade trees (page 51).

For detailed analysis on slow-growing evergreens, one specific plant type (*Taxus*) was chosen. While it is recognized that other slow-growing evergreens (i.e., *Buxus*) would have somewhat different requirements, it was felt that they would not vary significantly in cost from *Taxus*.

Costs were established for all factors of production including management and invested capital. Costs associated with factors of production supplied by owner/operators are often referred to as 'opportunity costs' or the income these factors could have received if they were employed elsewhere. For example, owners could usually be employed as managers at other nurseries, and money invested in land, buildings, irrigation systems, and equipment could have earned interest if invested in financial institutions.

Capital requirements for establishing the nurseries were first determined (1). Second, capital requirements per salable plant capacity by size of nursery were established (1). Third, annual fixed costs were calculated (see page 26). Fourth, annual variable costs were determined for each of the two-sized nurseries (Tables 1-3). Fifth, summaries were made for annual fixed and variable costs according to size of nursery (Table 4). This allowed cost comparisons based on size of nursery.

Most nurseries use cash rather than accrual accounting procedures. For this reason, the analyses were completed on a "cash" basis. This approach does not give a true economic picture of the cost of producing a plant since it does not take into account the time value of money from planting until harvest. The analyses do, however, give a reliable estimate of the annual cost per salable plant based upon the study's assumptions.

Total annual production costs consist of both fixed and variable factors. Fixed costs are primarily made up of implicit costs such as depreciation on buildings and equipment, interest charges (both for borrowed and equity capital), and charges for management. Many nurserymen do not adequately consider fixed costs when computing costs of production. Fixed items are often considered as residual claimants on income. For example, management is compensated if all other factors of production have been accounted for. As noted previously, annual fixed costs are discussed in greater detail in a companion article.

TABLE 1. Variable Cost (Dollars) for Slow-Growing Evergreens *(Taxus)* for a 50-Acre* Field Nursery in Ohio, 1985.

Item	Description	Unit	Cost per Unit† ($)	Quantity	Total Variable Cost ($)
Propagation‡					
Rooting media	Sand	cu yd	6.50	9.00	58
Collecting, stripping, and sticking	7914 units @ 1200/hr	hr	6.93**	6.60	46
Maintenance	50% of total propagation maintenance hr	hr	6.93	365.00	2,530
Harvest	7914 units @ 600/hr	hr	6.93	13.19	91
Hormone powder	#8, I.B.A.	lb	15.50	0.23	4
Subtotal					2,729
Materials					
Burlap	32" x 32" squares + twine	ea	0.45	4,140.00	1,863
Polyethylene film	4 mil white, 32' x 225'	ea	127.50	1.04	133
Strip tags	5/8" x 7" plastic strip tags	ea	0.02	4,140.00	83
Chemicals	Custom spread, custom blend: 45-0-0, 0-44-0, 0-0-60 (fertilizer)	ton	176.00	0.72	127
	Custom spread (lime)	ton	20.00	1.28	26
	Urea, 45-0-0 (fertilizer)	ton	220.00	1.38	304
	Soluble 20-20-20 (fertilizer)	ton	1,411.20	0.14	198
	Trifluralin 4 EC (Treflan) (herbicide)	gallon	33.49	0.32	11
	Simazine 80WP (Princep) (herbicide)	lb	3.75	17.45	65
	DCPA 75WP (Dacthal) (herbicide)	lb	6.37	50.69	323
	Malathion, 57EL (Cythion) (insecticide)	gallon	18.28	16.34	299
	Benomyl, 50WP (Benlate) (fungicide)	lb	14.17	10.89	154
	Carbaryl, 80WP (Sevin) (insecticide)	lb	6.09	27.23	166
	Chlorothalonil 10M cu ft (Termil) (fungicide)	canister	1.76	3.12	5
	Other (*i.e.*, Kelthane, Captan, Di-syston, Orthene, etc.)††				310
Subtotal					4,067

TABLE 1 (continued). Variable Cost (Dollars) for Slow-Growing Evergreens *(Taxus)* for a 50-Acre* Field Nursery in Ohio, 1985.

Item	**Description**	**Unit**	**Cost per Unit† ($)**	**Quantity**	**Total Variable Cost ($)**
Machinery and Equipment					
	Tractor, 100 hp	hr	17.00	32.54	553
	Tractor, 34 hp	hr	4.99	32.31	161
	Articulated loader/3,000 lb	hr	14.81	26.98	400
	Forks	hr	0.01	73.24	1
	Plow, 3-14″	hr	6.57	1.02	7
	Disk, 8′ wide	hr	4.23	2.09	9
	Harrow, 10′ wide	hr	8.45	0.16	1
	Cultimulcher, 10′ wide	hr	24.70	0.31	8
	Spray rig with 10′ boom	hr	2.77	2.76	8
	Transplanter, 3-row	hr	26.79	1.23	33
	Permanent irrigation/well and pump 100 hp	hr	7.60	86.28	656
	In-ground irrigation — bed/field area	hr	3.13	72.00	225
	Above-ground irrigation — bed area	hr	1.83	72.00	132
	In-ground irrigation — storage and holding	hr	5.65	12.00	68
	Above-ground irrigation — storage and holding	hr	11.05	12.00	133
	Traveler gun	hr	12.06	2.28	28
	Portable PTO pump, 40 hp (emergency)	hr		(no costs budgeted)	
	Airblast sprayer	hr	1.01	21.78	22
	Fertilizer injector	hr	12.39	4.50	56
	Transplanter, 2-row	hr	12.00	2.03	24
	Undercutter, bed	hr	1.16	1.17	1
	U-Blade	hr	17.56	0.38	7
	Sidedresser, 2-row	hr	0.63	7.53	5
	Cultivator, 2-row	hr	0.95	12.56	12
	Wagon, 4-wheel	hr	0.48	10.80	5
	Cultivator, 3-row	hr	13.93	1.38	19
	Truck, 1/2-ton pickup	hr	8.42	346.67	2,919
	Flatbed truck, 24′ bed	hr	14.87	26.98	401
Subtotal					5,894
Labor					
	Labor hours	hr	6.93**	1,369.51	9,491
	Related labor hours, 20%	hr	6.93	273.90	1,898
Subtotal					11,389
Interest Charge on Operating Capital	Computed at 12% on an annual basis for 6 months	%	6.0 (0.06)	24,079.00	1,445
Total Variable Costs					25,524
Variable Cost per 18-24″ Salable Plant	Units available for sale in a given year	ea		4,140.00	6.17

*Total nursery = 50 acres, with 40 acres of growing space and 10 acres in production facilities, holding and field bed area, roads, etc. Group I plants = 10 acres, with 8 acres of growing space and 2 acres in production facilities, holding and field bed area, roads, etc. 4,140 18-24″ salable plants per year.

†Quantity discounts were applied to chemicals and other items.

‡7,914 plants would be stuck in the propagation house annually and about 23% would be lost over a 2-year period, leaving 6,088 for transplanting into liner beds. About 20% of the plants in the liner beds would be lost over a 3-year period, leaving 4,870 for transplanting into the field.

**Average basic wage before withholding taxes and fringe benefits = $5.25, taxes and fringe benefits add 32% or $1.68 for a total of $6.93.

††To achieve better pest and disease control, alternative chemical usage is advisable. Alternative chemical costs were estimated at 50% of the cost of Malathion, Benomyl, and Carbaryl.

TABLE 2. Variable Cost (Dollars) for Slow-Growing Evergreens *(Taxus)* for a 200-Acre* Field Nursery in Ohio, 1985.

Item	Description	Unit	Cost per Unit† ($)	Quantity	Total Variable Cost ($)
Propagation‡					
Rooting media	Sand	cu yd	6.50	18.00	117
Collecting, stripping and sticking	37,710 units @ 1200/hr	hr	6.93**	31.43	218
Maintenance	50% of total propagation maintenance hr	hr	6.93	400.00	2,772
Harvest	37,710 units @ 600/hr	hr	6.93	62.85	436
Hormone powder	#8, I.B.A.	lb	15.50	1.08	17
Subtotal					3,560
Materials					
Burlap	32" x 32" squares + twine	ea.	0.45	18,156.00	8,170
Polyethylene film	4 mil white, 32' x 225'	ea	127.50	4.54	579
Strip tags	5/8" x 7" plastic strip tags	ea	0.02	18,156.00	363
Chemicals	Custom spread, custom blend: 45-0-0, 0-44-0, 0-0-60 (fertilizer)	ton	176.00	3.17	558
	Custom spread (lime)	ton	20.00	5.16	103
	Urea, 45-0-0- (fertilizer)	ton	220.00	5.50	1,210
	Soluble 20-20-20 (fertilizer)	ton	1,411.20	0.55	776
	Trifluralin 4 EC (Treflan) (herbicide)	gallon	33.49	1.40	47
	Simazine 80WP (Princep) (herbicide)	lb	3.75	79.58	298
	DCPA 75WP (Dacthal) (herbicide)	lb	6.37	208.89	1,331
	Malathion, 57EL (Cythion) (insecticide)	gallon	18.28	71.61	1,309
	Benomyl, 50WP (Benlate) (fungicide)	lb	14.17	24.75	351
	Carbaryl, 80WP (Sevin) (insecticide)	lb	6.09	119.36	727
	Chlorothalonil 10M cu ft (Termil) (fungicide)	canister	1.76	13.36	24
	Other (*i.e.,* Kelthane, Captan, Di-syston, Orthene, etc.)††				1,224
Subtotal					17,070
Machinery and Equipment					
	Tractor, 100 hp	hr	17.00	18.73	318
	Tractor, 60 hp	hr	11.68	23.77	278
	Tractor, 34 hp	hr	4.99	141.56	706
	Articulated loader/2,000 lb	hr	6.67	82.25	549
	Articulated loader/3,000 lb	hr	14.81	82.25	1,218
	Forks	hr	0.01	164.50	2
	Plow, 3-14"	hr	6.57	4.49	29
	Disk, 8' wide	hr	4.23	9.09	38
	Harrow, 10' wide	hr	8.45	0.67	6
	Cultimulcher, 10' wide	hr	24.70	1.34	33
	Spray rig with 10' boom	hr	2.77	12.01	33
	Transplanter, 3-row	hr	26.79	5.34	143
	Permanent irrigation/well and pump 100 hp	hr	7.60	118.00	897
	In-ground irrigation — bed/field area	hr	3.13	96.00	300
	Above-ground irrigation — bed area	hr	1.83	96.00	176
	In-ground irrigation — storage and holding	hr	5.65	12.00	68
	Above-ground irrigation — storage and holding	hr	11.05	12.00	133
	Traveler gun	hr	12.06	10.00	121
	Portable PTO pump, 40 hp (emergency)	hr		(no costs budgeted)	
	Airblast sprayer	hr	1.01	95.49	96
	Fertilizer injector	hr	12.39	4.50	56
	Transplanter, 2-row	hr	12.00	8.90	107
	Undercutter, bed	hr	1.16	5.13	6
	U-Blade	hr	17.56	1.65	29

*Total nursery = 200 acres, with 175 acres of growing space and 25 acres in production facilities, holding and field bed area, roads, etc. Group I plants = 40 acres, with 35 acres of growing space and 5 acres in production facilities, holding and field bed area, roads, etc., 18,156 18-24" salable plants per year.

†Quantity discounts were applied to chemicals and other items.

‡34,710 plants would be stuck in the propagation house and about 23% would be lost, leaving 26,700 for transplanting into liner beds. About 20% of the plants in the liner beds would be lost, leaving 21,360 for transplanting into the field.

**Average basic wage before withholding taxes and fringe benefits = $5.25, taxes and fringe benefits add 32% or $1.68 for a total of $6.93.

††To achieve better pest and disease control, alternative chemical usage is advisable. Alternative chemical costs were estimated at 50% of the cost of Malathion, Benomyl, and Carbaryl.

TABLE 2 (continued). Variable Cost (Dollars) for Slow-Growing Evergreens *(Taxus)* for a 200-Acre* Field Nursery in Ohio, 1985.

Item	Description	Unit	Cost per Unit† ($)	Quantity	Total Variable Cost ($)
Machinery and Equipment (continued)					
	Sidedresser, 2-row	hr	0.63	33.00	21
	Cultivator, 2-row	hr	0.95	59.40	56
	Wagon, 4-wheel	hr	0.48	47.30	23
	Cultivator, 3-row	hr	13.93	6.03	84
	Truck, 1/2-ton pickup	hr	8.42	520.00	4,378
	Flatbed truck, 24' bed	hr	14.87	123.38	1,835
Subtotal					11,739
Labor					
	Labor hours	hr	6.93**	5,356.02	37,117
	Related labor hours, 20%	hr	6.93	1,071.20	7,423
Subtotal					44,540
Interest Charge on Operating Capital	Computed at 12% on an annual basis for 6 months	%	6.0 (0.06)	76,909.00	4,615
Total Variable Costs					81,524
Variable Cost per 18-24" Salable Plant	Units available for sale in a given year	ea		18,156.00	4.49

*Total nursery = 200 acres, with 175 acres of growing space and 25 acres in production facilities, holding and field bed area, roads, etc. Group I plants = 40 acres, with 35 acres of growing space and 5 acres in production facilities, holding and field bed area, roads, etc., 18,156 18-24" salable plants per year.

†Quantity discounts were applied to chemicals and other items.

‡34,710 plants would be stuck in the propagation house and about 23% would be lost, leaving 26,700 for transplanting into liner beds. About 20% of the plants in the liner beds would be lost, leaving 21,360 for transplanting into the field.

**Average basic wage before withholding taxes and fringe benefits = $5.25, taxes and fringe benefits add 32% or $1.68 for a total of $6.93.

††To achieve better pest and disease control, alternative chemical usage is advisable. Alternative chemical costs were estimated at 50% of the cost of Malathion, Benomyl, and Carbaryl.

Variable Costs

Variable costs are comprised of all cost factors that vary with the quantity of plants being grown at one point in time. Variable costs are explicit, obvious, and normally paid out yearly. An example of variable costs is the amount of burlap that would be needed yearly for harvesting *Taxus* in a ball-and-burlap operation. Variable costs were divided into the following categories: propagation, materials, machinery and equipment, labor, and interest on operating capital (Tables 1 and 2).

Propagation. Propagation costs included rooting media (sand), labor for collecting, stripping, sticking, maintainance, and harvesting, as well as for hormone powder.

Burlap and twine. Nails, burlap, and twine were provided for "ball and burlapping" each plant produced. The cost of the nails, burlap, and twine reflects a delivered cost to the nursery.

Polyethylene film. The cost of the white copolymer film delivered to the nursery.

Strip tags. Strip tags were provided for identifying plants by botanical name, common name, state where plant was grown, and nursery producer. Costs include printing and shipping charges.

Chemicals. Chemical costs were organized around three cultural programs. The first is the fertilizer. For field operations the price included custom spreading for a custom blend of fertilizer and for lime. Price for urea included delivery to the nursery. The cost of herbicide, the second expense, is the purchase price of the various pre-emergence and post-emergence materials. The third combines insecticides and fungicides. Purchase price reflects total cost for the chemicals quoted by local distributors. A special category of "other " was included under chemicals. Adequate chemicals were budgeted for normal control of insects and diseases. The "other" category, budgeted at 50 percent of the cost of the "normal" insecticides and fungicides, was to handle special problems.

Machinery and equipment. Variable machinery and equipment costs represent all costs incurred while equipment and machinery is in use. These costs include repair, fuel, and lubrication/filter (Table 3). Repair cost per hour was calculated by multiplying initial cost by a stated repair percentage divided by the estimated lifetime use of the machinery in the 200-acre nursery in hours. The same repair cost per hour was used for both sized nurseries. Fuel costs were determined by multiplying units of fuel used per hour by the price per unit. Filter/lubrication cost was estimated at a constant factor of 15 percent of calculated fuel costs. Summation of repair, fuel, and filter/lubrication costs result in total variable cost per hour of machinery or equipment useage.

TABLE 3. Estimated Variable Cost per Hour of Use for Machinery and Equipment for Field Nurseries in Ohio, 1985.

Item Number	Item	New Cost ($)	Expected Life (yr.)	Estimated Annual Use: 50 Acre* Nursery (hr.)	Estimated Annual Use: 200 Acre† Nursery (hr.)	Estimated Cost per Hour of Use: Repairs‡ ($)	Fuel** ($)	Lubrication and Filter ($)	Total ($)
1	Tractor, 75 hp	28,278	10	217	494	5.15	10.30	1.55	17.00
2	Tractor, 60 hp	20,419	10	—	583 ea.	3.15	7.42	1.11	11.68
3	Tractor, 34 hp	14,504	10	169	632	2.07	2.54	0.38	4.99
4	Flatbed truck	42,000	10	383	1,702	2.22	11.00	1.65	14.87
5	Articulated loader/2,000 lb	25,000	10	—	600	3.75	2.54	0.38	6.67
6	Articulated loader/3,000 lb	38,000	10	328	600	5.70	7.92	1.19	14.81
7	Tree spade	8,490	2	181	641	5.30			5.30
8	Forks for loaders	1,100	10	328	1,200	0.01			0.01
9	Plow	2,616	10	8	32	6.57			6.57
10	Disk	3,900	10	15	60	4.23			4.23
11	Harrow	650	10	2	5	8.45			8.45
12	Cultimulcher	3,800	10	3	10	24.70			24.70
13	Spray rig (boom sprayer)	1,407	7	13	58	2.77			2.77
14	Transplanter, 3-row	7,500	10	5	21	26.79			26.79
15	Transplanter, 1-row	5,000	10	93	407	0.92			0.92
16	Permanent irrigation, well + pump	36,396	20	221	323	0.56	6.12	0.92	7.60
17	In-ground irrigation/bed-field††	34,606	20	151	221	3.13			3.13
18	Above-ground irrigation/bed-field††	4,345	5	144	190	1.83			1.83
19	In-ground irrigation/storage/holding††	16,957	20	60	60	5.65			5.65
20	Above-ground irrigation storage/holding††	8,286	5	60	60	11.05			11.05
21	Traveler gun††	22,000	10	17	73	12.06			12.06
22	Portable irrigation pump (emergency)	425	10	—	—	—	—	—	—
23	Airblast sprayer	3,600	7	94	406	1.01			1.01
24	Fertilizer injector	858	5	9 ea.	9 ea.	12.39			12.39
25	Transplanter, 2-row	5,600	10	8	35	12.00			12.00
26	Undercutter—bed	285	7	5	21	1.16			1.16
27	U-Blade—field	240	5	0.38	1.65	17.65			17.65
28	Fertilizer sidedresser	1,000	10	24	103	0.63			0.63
29	Cultivator, 2-row	1,750	7	44	172	0.95			0.95
30	Wagon	1,978	10	57 ea.	249 ea.	0.48			0.48
31	Cultivator, 3-row	2,250	7	4	15	13.93			13.93
32	Truck—1/2-ton pickup	13,485	5	1,771	2,779	4.37	3.52	0.53	8.42
33	Mower	2,283	10	9	46	2.98			2.98
34	Seeder	175	10	4	10	1.05			1.05

*50 total acres.

†200 total acres.

‡Repairs per hour were based on usage of the large nursery. They were computed on the basis of percent of new cost over the life of the asset. Percent factors used were: 90 for items 1, 2, 3, 4, 5, 6, 32; 80 for items 9, 13, 23; 75 for items 14, 15, 25, 28; 65 for items 10, 11, 12, 24, 29, 31; 60 for items 26, 27, 30, 33, 34; 40 for items 7, 17, 18, 19, 20, 21, 22; and 10 for items 8, 16. The total was then divided by the estimated total number of hours the equipment would be an asset.

**Fuel was estimated at $1.10 per gallon for gasoline-driven items, $1.03 for diesel-driven items, and $0.31 per killowatt for electrical-driven items.

††Cost is for a large nursery on which variable costs per hour were based. Cost for the small nursery was lower.

Hourly labor. The hourly basic wage was estimated at $5.25. An additional 32 percent or $1.68 was allocated for various fringe benefits making a total hourly labor cost of $6.93. Each major production activity was allocated necessary labor hours to accomplish assigned tasks.

Cost Summaries

After all cost factors were determined, they were summarized based upon cost per salable plant by size of nursery.

RESULTS AND DISCUSSION

Annual fixed, variable, and total production costs of producing slow-growing evergreens (Taxus) in the field in Ohio for 1985 are summarized in Table 4. In the 50-acre nursery, total annual costs were $72,426 or $17.47 per salable 18-24 inch plant. Fixed costs totaled $46,902 or $11.31 per plant, making up 65 percent of total costs. Based on percentage of total costs, land and improvements made up 10 percent, buildings 7 percent, machinery and equipment 18 percent, general overhead 28 percent,

TABLE 4. Summary of Annual Fixed, Variable, and Total Costs (Dollars) of Producing Slow-Growing Evergreens (*Taxus*) in the Field in Ohio, 1985.

	50 Acre Field Nursery*			200 Acre Field Nursery†		
Item	**Cost**	**Cost per Salable Plant**	**Percent of Total Cost**	**Cost**	**Cost per Salable Plant**	**Percent of Total Cost**
Fixed Cost Items						
Land and Improvements	7,061	1.70	10	21,716	1.20	13
Buildings	4,740	1.14	7	6,811	.38	4
Machinery and Equipment	13,173	3.18	18	25,495	1.40	15
General Overhead	20,592	4.97	28	32,685	1.80	19
Interest on General Overhead, Insurance, and Taxes	1,336	.32	2	2,198	.12	1
Subtotal	46,902	11.31	65	88,905	4.09	52
Variable Cost Items						
Propagation	2,729	.66	4	3,560	.20	2
Materials	4,067	.98	5	17,070	.94	10
Machinery and Equipment	5,894	1.42	8	11,739	.65	7
Labor	11,389	2.75	16	44,540	2.45	26
Interest on Operating Capital	1,445	.35	2	4,615	.25	3
Subtotal	25,529	6.16	35	81,524	4.49	48
TOTAL ANNUAL COSTS	72,426	17.47	100	170,429	9.39	100

* Total Nursery—50 acres, 40 acres of growing space, 10 acres production facilities, holding and field bed area, roads, etc. Slow-Growing Evergreens—10 acres, 8 acres of growing space, 2 acres production facilities, holding and field bed area roads, etc.

† Total Nursery—200 acres, 175 acres of growing space, 25 acres production facilities, holding and field bed area, roads, etc. Slow-growing Evergreens—40 acres, 35 of growing space, 5 acres production facilities, holding and field bed area, roads, etc.

and interest on general overhead, insurance, and taxes 2 percent. Variable costs totaled $25,529 or $6.16 per plant and made up 35 percent of total costs. Based on percentage of total costs, propagation made up 4 percent, materials 5 percent, machinery and equipment 8 percent, labor 16 percent, and interest on operating capital 2 percent.

In the 200-acre nursery, total annual costs were $170,429 or $9.39 per salable 18-24 inch plant. Fixed costs totaled $88,905 or $4.90 per plant and made up 52 percent of total costs. Based on percentage of total costs, land and improvements made up 13 percent, buildings 4 percent, machinery and equipment 15 percent, general overhead 19 percent, and interest on general overhead, insurance, and taxes 1 percent. Variable costs totaled $81,524 or $4.49 per plant and made up 48 percent of total costs. Based on percentage of total costs, propagation made up 2 percent, materials 10 percent, machinery and equipment 7 percent, labor 26 percent, and interest on operating capital 3 percent.

Total annual costs were $8.08 per plant more in the 50-acre nursery than in the 200-acre. Of this $8.08, $6.41 or 80 percent were comprised of fixed costs. On a per-item basis, the 200-acre nursery's advantages were 50 cents on land and improvements, 76 cents on buildings, $1.78 on machinery and equipment, $3.17 on general overhead, and 20 cents on interest for general overhead, insurance, and taxes. The $1.67 difference for variable costs was 46 cents for propagation, 4 cents for material, 77 cents for machinery and equipment, 30 cents for labor, and 10 cents for interest on operating capital.

In the nurseries analyzed, it cost 46 percent less to produce a 18-24 inch salable slow-growing evergreen (*Taxus*) in the 200-acre nursery than in the 50-acre. While the overall reduction was 46 percent, it was 57 percent for fixed costs and only 27 percent for variable costs. Large-sized commercial field nurseries are able to make more efficient use of buildings, equipment, machinery, labor, and general overhead than can small field nurseries.

One note of caution should be observed in comparing costs between the two sized nurseries. Each of the nurseries were analyzed based on the assumption that they would produce a diverse line of plants that included both shrubs and trees.

This assumption might be unrealistic for the 50-acre nursery as a considerable amount of specialized equipment was required. It should also be noted that many operators of small nurseries might choose a different line of equipment than that budgeted. While the equipment budgeted is labor saving, smaller nurserymen might have a surplus of family labor and choose less expensive, less labor saving equipment. Also, a small nursery might well operate its office out of a home.

Individual nurserymen might experience, or at least calculate, costs considerably differently than those depicted here. Most cost differences would probably be reflected in fixed rather than variable costs. Most fixed costs are implicit and their full impact may not be calculated by established nurserymen. Budgets presented assumed new facilities, machinery, and equipment. Most nurserymen have owned their land for many years and have used machinery and equipment. For the established nursery, budgeted fixed costs on land improvements, buildings, machinery, and equipment presented here would reflect replacement rather than 'book' value of depreciated items. Presented fixed costs also placed a market value on management. Many nurserymen place little if any value on their own management when computing costs. Variable items, on the other hand, are explicit, experienced at least yearly, and easily accounted for. Variable costs presented here would be typical for the industry in Ohio and should be rather consistent regardless of age and size of the nursery.

IMPLICATIONS

Total annual costs per 18-24 inch salable slow growing evergreen (*Taxus*) were $17.47 in the 50-acre field nursery and $9.39 in the 200-acre field nursery. Fixed costs were $11.31 in the 50-acre nursery and $4.90 in the 200-acre nursery for a differential of $6.41 per salable plant. Variable costs were $6.16 in the 50-acre and $4.49 in the 200-acre for a differential of $ 1.67. These plant costs assumed propagation in the nursery (18 months), liner production in beds (three years), and field growing (six years), ball and burlapped harvesting, and an average size of 18-24 inches per salable plant.

These figures demonstrated that variable costs on a salable plant basis, at least over the size range of nurseries analyzed, were about 27 percent less when going from a 50-acre nursery to a 200-acre nursery This reduction was primarily accounted for by efficiencies gained in propagation and machinery and equipment. Fixed costs were reduced significantly as size of nursery was increased. This occurred because most of the fixed factors required to operate the 50-acre nursery, such as management, buildings, and most machinery and equipment, were also adequate to operate the 200-acre. As the size of nursery increased, costs for fixed items of production were spread over more salable units, thereby reducing the fixed cost per plant.

LITERATURE CITED

1. Taylor, Reed D., Harold H. Kneen, Elton M. Smith, David E. Hahn, and Stanley Uchida. 1986. Costs of Establishing and Operating Field Nurseries Differentiated by Size of Firm and Species of Plant in U.S.D.A. Plant Hardiness Zones Five and Six. Southern Coop. Ser. Bull. 315.

Costs of Producing Deciduous Shrubs (*Viburnum*) in the Field by Size of Firm in Ohio

REED D. TAYLOR, HAROLD H. KNEEN, ELTON M. SMITH,
DAVID E. HAHN and STANLEY UCHIDA[1]

ABSTRACT

In this study annual production costs for field-grown deciduous shrubs in Ohio-sized firms were determined. This was accomplished by synthesizing two model field nurseries using the conceptual framework of economic engineering. Once the nurseries were synthesized, growing space was divided into five equal parts with each part being assigned a plant group. Eight acres of growing space were allocated to shrub research in the 50-acre nursery while 35 acres were devoted in the 200-acre nursery. One specific species of deciduous shrub (*Viburnum*) was chosen for detailed analysis. In the space allocated, 6,208 salable *Viburnum*, 3-4 foot tall could be produced annually in the 50-acre nursery and 27,162 in the 200-acre nursery. Total costs per salable plant were $12.00 in the 50-acre nursery and $7.07 in the 200-acre nursery, based on 1985 figures.

INTRODUCTION

Deciduous shrubs including various species of *Viburnum, Forsythia, Weigela,* and *Liqustrum,* are important in the Ohio landscape business. As a group they encompass a wide range of growing habits, size, foliage, flower, and fruit colors and they can be effectively used in many ways in landscaping. Most deciduous shrubs being grown in Ohio are quite hardy and require only minimum overwinter protection even when raised in containers.

The specific objective of this study was to determine annual production costs for deciduous shrubs grown in the field in two sizes of firms. This information should aid Ohio nurserymen in their decisions regarding which plants to grow and in what quantities.

MATERIALS AND METHODS

In the study, two model firms were synthesized using the conceptual framework of economic engineering wherein the 'best proven practice' was included in each model. They were synthesized based on conditions observed in the vicinity of Columbus, Ohio. The complete synthesis included developing an appropriate production cycle; schematic drawings of the physical layout, including buildings and irrigation systems; lists of equipment and other items; a complete sequence by month and year of nursery operational steps beginning with propagation and ending with loading the finished product for wholesale distribution; and budgets for fixed and variable costs.

Data for this study were obtained in Ohio during 1985 from wholesale nurseries and nursery suppliers. The basic goals in synthesizing the production facilities were to minimize labor expenses, flow and movement of plant material and equipment, water runoff, and initial investment, and to maximize the number of salable plants and keep future expansion possible. See Taylor et al. (1) for a detailed analysis of the physical plant, production system, and capital production budgets.

The first step in the production cycle consists of collecting cuttings from field plants that are at least two years old. Cuttings were trimmed and treated with a hormone solution and stuck in a heated sand bed in an "overwintering" house. During March of the second production year, the nine-month-old rooted cuttings are pulled from the propagation beds, root pruned by hand, and planted seven inches within rows, spaced 20 inches apart between rows, into four feet wide beds. After one year in the beds, they are dug, root and top pruned by hand, and planted in the field. Approximately 25 percent of the crop will be harvested and sold during the fall of the third field production year and another 25 percent dug, overwintered, and sold during late winter and early spring of the fourth field production year. The remaining 50 percent of the crop will be harvested and sold during later winter and spring of the fourth field production year. After the harvest is complete, the land is left fallow and disked for weed control four times during summer months. The fields are plowed in the fall of the fourth field production year in preparation for spring planting.

A model facility was synthesized for both a 50-acre and a 200-acre field nursery. The nursery operations were assumed to produce a diverse line of nursery stock each having its own unique production cycle. Commonly grown nursery stock was divided into five groups. While not all inclusive, the groups do permit developing a range of per unit costs related to input costs and cultural factors. For analytical purposes, it was assumed that each group would occupy 20 percent of the field growing area (i.e., 50-acre nursery = 8 acres per group, 200-acre nursery = 35 acres per group). In addition to the field growing area, the 50-acre nursery had 10 acres and the 200-acre nursery 25 acres of production facilities including overwintering houses, propagation facilities, shipping area, holding area, liner bed area, pond, supply shed, machinery storage, machine shop, office, and rest rooms. Costs deve-

[1]Associate Professor, and former graduate student, Dept. of Agricultural Economics and Rural Sociology; Professor, Dept. of Horticulture; and Professor, and graduate student, Dept of Agricultural Economics and Rural Sociology, The Ohio State University. Mr. Kneen is currently Director of Marketing, Studebaker Nurseries, Inc., New Carlisle, Ohio. Mr. Uchida works for BANCOHIO, Columbus, Ohio.
In addition to research, Drs. Taylor, Smith, and Hahn hold appointments in the Ohio Cooperative Extension Service.

loped on deciduous shrubs (*Viburnum*), therefore, were based on the scale of complete nurseries, but were analyzed on the basis of percent of total space occupied. Companion studies in this publication report on fixed costs (page 26), slow-growing evergreens (page 37), and shade trees (page 51).

For detailed analysis on deciduous shrubs, one specific plant type (*Viburnum*) was chosen. While it is recognized that other deciduous shrubs (i.e., *Forsythia*) would have somewhat different requirements, it was felt that their costs would not vary significantly from *Viburnum*.

Costs were established for all factors of production including management and invested capital. In economic terms, costs associated with factors of production supplied by owner/operators are often referred to as 'opportunity costs' or the income these factors could have received if they were employed elsewhere. For example, owners could usually be employed as managers at other nurseries, and money invested in land, buildings, irrigation systems, and equipment could have earned interest if it had been placed in financial institutions.

Capital requirements for establishing the nurseries were first determined (1). Second, capital requirements per salable plant capacity by size of nursery were established (1). Third, annual fixed costs were calculated (see page 26). Fourth, annual variable costs were determined for each of the two-sized nurseries (Tables 1-2). Fifth, summaries were made for fixed and variable costs according to size of nursery (Table 3). This allowed cost comparisons based on size of nursery.

Most nurseries use cash rather than accrual accounting. For this reason, the analyses were completed on a "cash" basis. This approach does not give a complete economic picture of the cost of producing a plant as it does not take into account the time value of money from the time the plant is planted until it is harvested. The analyses do, however, give a reliable estimate of the annual cost per salable plant based upon the study's assumptions.

Total annual production costs consist of both fixed and variable factors. Fixed costs are composed of implicit costs such as depreciation on buildings and equipment, interest charges (both for borrowed and equity capital), and charges for management. Many nurserymen do not adequately consider fixed costs when computing costs of production. Fixed items are often considered as residual claimants on income. For example, management is compensated if all other factors of production have been accounted for. As noted previously, annual fixed costs are discussed in greater detail in a companion article.

Variable costs include all costs that vary with the quantity of plants being grown. Variable costs are explicit, obvious, and normally paid out yearly. An example of variable costs is the amount of fertilizer that would be needed yearly for harvesting (*Viburnum*). Variable costs were subdivided into the following categories:propagation, materials, machinery and equipment, labor, and interest on operating capital (Tables 1 and 2). Details on specific variable costs, other than liners, are included in the companion article on slow-growing evergreens (page 37).

RESULTS AND DISCUSSION

Annual fixed, variable, and total production costs of producing deciduous shrubs (*Viburnum*) in the field in Ohio for 1985 are summarized in Table 3. In the 50-acre nursery, total annual costs were $74,546 or $12 per salable 3-4 foot tall plant. Fixed costs totaled $46,902 or $7.56 per plant and made up 63 percent of total costs. Based on percentage of total costs, land and improvements made up 9 percent, buildings 6 percent, machinery and equipment 18 percent, general overhead 28 percent, and interest on general overhead, insurance, and taxes 2 percent. Variable costs totaled $27,644 or $4.44 per plant and made up 37 percent of total costs. Based on percentage of total costs, propagation made up 3 percent, materials 6 percent, machinery and equipment 8 percent, labor 18 percent, and interest on operating capital 2 percent.

In the 200-acre nursery, total annual costs were $192,167 or $7.07 per salable 3-4 foot tall plant. Fixed costs totaled $88,905 or $3.27 per plant and made up 46 percent of total costs. Based on percentage of total costs, land and improvements made up 11 percent, buildings 4 percent, machinery and equipment 13 percent, general overhead 17 percent, and interest on general overhead, insurance, and taxes 1 percent. Variable costs totaled $103,262 or $3.80 per plant and made up 54 percent of total costs. Based on percentage of total costs, propagation made up 1 percent, materials 11 percent, machinery and equipment 8 percent, labor 31 percent, and interest on operating capital 3 percent.

Total annual costs were $4.93 per plant more in the 50-acre nursery than in the 200-acre. Of this $4.93, $4.29 or 87 percent were made up of fixed costs. On a per item basis, the 200-acre nursery's advantages were 34 cents on land and improvements, 51 cents on buildings, $1.18 on machinery and equipment, $2.12 on general overhead, and 14 cents on interest for general overhead, insurance, and taxes. The 64-cent difference for variable costs was 16 cents for propagation, 1 cent for materials, 44 cents for machinery and equipment, 2 cents for labor, and 3 cents for interest on operating capital.

In the nurseries analyzed, it cost 41 percent less to produce a 3-4 foot tall deciduous shrub (*Viburnum*) in the 200-acre nursery than in the 50-acre. While the overall reduction was 41 percent, it was 57 percent for fixed costs and only 16 percent for variable. Large-sized commercial field nurseries are able to make more efficient use of buildings, equipment, machinery, labor, and general overhead than is the case for small field nurseries.

One note of caution should be observed in comparing costs between the two sized nurseries. Each of the nurseries were analyzed based on the assumption that they would produce a diverse line of plants, both shrubs and trees. This assumption might be unrealistic for the 50-acre nursery as a considerable amount of specialized equipment was required. It should also be noted that many operators of smaller nurseries might choose a different line of equipment than that budgeted. While the equipment budgeted is labor saving, smaller nurserymen might have a surplus of family labor and choose less expensive, less labor-saving equipment. Also, a small nursery might well operate its office of a home.

TABLE 1. Variable Cost (Dollars) for Deciduous Shrubs *(Viburnum)* for a 50-Acre* Field Nursery in Ohio, 1985.

Item	Description	Unit	Cost per Unit† ($)	Quantity	Total Variable Cost ($)
Propagation‡					
Rooting media	Sand	cu yd	6.50	12.00	78
Collecting, stripping and sticking	11,869 units @ 1000/hr	hr	6.93**	11.87	82
Maintenance	25% of total propagation maintenance hr	hr	6.93	182.50	1,265
Harvest	11,869 units @ 400/hr	hr	6.93	29.68	206
Hormone powder	#1, I.B.A.	lb	8.00	0.34	3
Subtotal					1,634
Materials					
Burlap	32" x 32" squares + twine	ea	0.45	6,208.00	2,794
Polyethylene film	4 mil white, 32' x 225'	ea	127.50	1.55	198
Strip tags	5/8" x 7" plastic strip tags	ea	0.02	6,208.00	124
Chemicals	Custom spread, custom blend: 45-0-0, 0-44-0, 0-0-60 (fertilizer)	ton	176.00	1.25	220
	Custom spread (lime)	ton	20.00	1.21	24
	Urea, 45-0-0- (fertilizer)	ton	220.00	0.66	145
	Soluble 20-20-20 (fertilizer)	ton	1,411.20	0.06	85
	Trifluralin 4 EC (Treflan) (herbicide)	gallon	33.49	0.55	18
	Simazine 80WP (Princep) (herbicide)	lb	3.75	15.53	58
	DCPA 75WP (Dacthal) (herbicide)	lb	6.37	43.47	227
	Malathion, 57EL (Cythion) (insecticide)	gallon	18.28	13.97	255
	Benomyl, 50WP (Benlate) (fungicide)	lb	14.17	9.32	132
	Carbaryl, 80WP (Sevin) (insecticide)	lb	6.09	23.29	142
	Chlorothalonil 10M cu ft (Termil) (fungicide)	canister	1.76	4.65	8
	Other (*i.e.,* Kelthane, Captan, Di-syston, Orthene, etc.)††				265
Subtotal					4,745
Machinery and Equipment					
	Tractor, 100 hp	hr	17.00	35.58	605
	Tractor, 34 hp	hr	4.99	34.44	172
	Articulated loader/3,000 lb	hr	14.81	57.78	856
	Forks	hr	0.01	57.78	1
	Plow, 3-14"	hr	6.57	1.77	12
	Disk, 8' wide	hr	4.23	3.58	15
	Harrow, 10' wide	hr	8.45	0.27	2
	Cultimulcher, 10' wide	hr	24.70	0.54	13
	Spray rig with 10' boom	hr	2.77	2.57	7
	Transplanter, 3-row	hr	26.79	1.83	49
	Permanent irrigation/well and pump 100 hp	hr	7.60	40.00	304
	In-ground irrigation — bed area	hr	3.13	24.00	75
	Above-ground irrigation — bed area	hr	1.83	24.00	44
	In-ground irrigation — storage/ holding	hr	5.65	12.00	68
	Above-ground irrigation — storage/ holding	hr	11.05	12.00	133
	Traveler gun	hr	12.06	4.00	48
	Portable PTO pump, 40 hp	hr		(no costs budgeted)	
	Airblast sprayer	hr	1.01	18.63	19
	Fertilizer injector	hr	12.39	1.50	19
	Transplanter, 2-row	hr	12.00	3.04	36
	Undercutter, bed	hr	1.61	1.76	3
	Sidedresser, 2-row	hr	0.63	3.60	2
	Cultivator, 2-row	hr	0.95	11.88	11
	Wagon, 4-wheel	hr	0.48	16.16	8

*Total nursery = 50 acres, with 40 acres of growing space and 10 acres in production facilities, holding and field bed area, roads, etc. Group III plants = 10 acres, with 8 acres of growing space and 2 acres in production facilities, holding and field bed area, roads, etc., 6,208 salable plants (3-4' in height) per year.

†Quantity discounts were applied to chemicals and other items.

‡11,869 plants would be stuck in the propagation house and about 23% would be lost, leaving 9,130 for transplanting into liner beds. About 20% of the plants in the liner beds would be lost, leaving 7,304 for transplanting into the field.

**Average basic wage before withholding taxes and fringe benefits = $5.25, taxes and fringe benefits add 32% or $1.68 for a total of $6.93.

††To achieve better pest and disease control, alternative chemical usage is advisable. Alternative chemical costs were estimated at 50% of the cost of Malathion, Benomyl, and Carbaryl.

TABLE 1 (continued). Variable Cost (Dollars) for Deciduous Shrubs *(Viburnum)* for a 50-Acre* Field Nursery in Ohio, 1985.

Item	Description	Unit	Cost per Unit† ($)	Quantity	Total Variable Cost ($)
Machinery and Equipment (continued)					
	Cultivator, 3-row	hr	13.93	0.69	10
	Truck, 1/2-ton pickup	hr	8.42	346.71	2,919
	Flatbed truck, 24′ bed	hr	14.87	35.92	534
Subtotal					5,965
Labor					
	Labor hours	hr	6.93**	1,651.59	11,446
	Related labor hours, 20%	hr	6.93	330.32	2,289
Subtotal					13,735
Interest Charge on Operating Capital	Computed at 12% on an annual basis for 6 months	%	6.0 (0.06)	26,079.00	1,565
Total Variable Costs					27,644
Variable Cost per 3-4′ Salable Plant	Units available for sale in a given year	ea		6,208.00	4.45

*Total nursery = 50 acres, with 40 acres of growing space and 10 acres in production facilities, holding and field bed area, roads, etc. Group III plants = 10 acres, with 8 acres of growing space and 2 acres in production facilities, holding and field bed area, roads, etc., 6,208 salable plants (3-4′ in height) per year.

†Quantity discounts were applied to chemicals and other items.

‡11,869 plants would be stuck in the propagation house and about 23% would be lost, leaving 9,130 for transplanting into liner beds. About 20% of the plants in the liner beds would be lost, leaving 7,304 for transplanting into the field.

**Average basic wage before withholding taxes and fringe benefits = $5.25, taxes and fringe benefits add 32% or $1.68 for a total of $6.93.

††To achieve better pest and disease control, alternative chemical usage is advisable. Alternative chemical costs were estimated at 50% of the cost of Malathion, Benomyl, and Carbaryl.

TABLE 2. Variable Cost (Dollars) for Deciduous Shrubs *(Viburnum)* for a 200-Acre* Field Nursery in Ohio, 1985.

Item	Description	Unit	Cost per Unit† ($)	Quantity	Total Variable Cost ($)
Propagation‡					
Rooting media	Sand	cu yd	6.50	24.00	156
Collecting, stripping and sticking	51,927 units @ 1000/hr	hr	6.93**	51.93	360
Maintenance	25% of total propagation maintenance hr	hr	6.93	200.00	1,386
Harvest	51,927 units @ 400/hr	hr	6.93	129.93	900
Hormone powder	#1, I.B.A.	lb	8.00	1.49	12
Subtotal					2,814
Materials					
Burlap	32″ x 32″ squares + twine	ea	0.45	27,162.00	12,223
Polyethylene film	4 mil white, 32′ x 225′	ea	127.50	6.79	866
Strip tags	5/8″ x 7″ plastic strip tags	ea	0.02	27,162.00	543
Chemicals	Custom spread, custom blend: 45-0-0, 0-44-0, 0-0-60 (fertilizer)	ton	176.00	5.46	961
	Custom spread (lime)	ton	20.00	9.67	193
	Urea, 45-0-0- (fertilizer)	ton	220.00	2.89	636
	Soluble 20-20-20 (fertilizer)	ton	1,411.20	0.28	395
	Trifluralin 4 EC (Treflan) (herbicide)	gallon	33.49	2.42	81
	Simazine 80WP (Princep) (herbicide)	lb	3.75	67.93	255
	DCPA 75WP (Dacthal) (herbicide)	lb	6.37	190.19	1,212
	Malathion, 57EL (Cythion) (insecticide)	gallon	18.28	61.13	1,117
	Benomyl, 50WP (Benlate) (fungicide)	lb	14.17	40.76	578
	Carbaryl, 80WP (Sevin) (insecticide)	lb	6.09	101.89	621
	Chlorothalonil 10M cu ft (Termil) (fungicide)	canister	1.76	20.37	36
	Other (*i.e.*, Kelthane, Captan, Di-syston, Orthene, etc.)††				1,158
Subtotal					20,875

TABLE 2 (continued). Variable Cost (Dollars) for Deciduous Shrubs *(Viburnum)* for a 200-Acre* Field Nursery in Ohio, 1985.

Item	**Description**	**Unit**	**Cost per Unit† ($)**	**Quantity**	**Total Variable Cost ($)**
Machinery and Equipment					
	Tractor, 100 hp	hr	17.00	29.04	494
	Tractor, 60 hp	hr	11.68	125.56	1,467
	Tractor, 34 hp	hr	4.99	156.04	779
	Articulated loader/2,000 lb	hr	6.67	126.42	843
	Articulated loader/3,000 lb	hr	14.81	126.42	1,872
	Forks	hr	0.01	252.83	3
	Plow, 3-14″	hr	6.57	7.74	51
	Disk, 8′ wide	hr	4.23	15.67	66
	Harrow, 10′ wide	hr	8.45	1.16	10
	Cultimulcher, 10′ wide	hr	24.70	2.28	56
	Spray rig with 10′ boom	hr	2.77	11.28	31
	Transplanter, 3-row	hr	26.79	7.99	214
	Permanent irrigation/well and pump 100 hp	hr	7.60	61.50	467
	In-ground irrigation — bed area	hr	3.13	32.00	100
	Above-ground irrigation — bed area	hr	1.83	32.00	59
	In-ground irrigation — storage/holding	hr	5.65	12.00	68
	Above-ground irrigation — storage/holding	hr	11.05	12.00	133
	Traveler gun	hr	12.06	17.50	211
	Portable PTO pump, 40 hp	hr		(no costs budgeted)	
	Airblast sprayer	hr	1.01	78.75	80
	Fertilizer injector	hr	12.39	1.50	19
	Transplanter, 2-row	hr	12.00	13.31	160
	Undercutter, bed	hr	1.16	7.68	9
	Sidedresser, 2-row	hr	0.63	15.75	10
	Cultivator, 2-row	hr	0.95	34.66	33
	Wagon, 4-wheel	hr	0.48	70.76	34
	Cultivator, 3-row	hr	13.93	3.04	42
	Truck, 1/2-ton pickup	hr	8.42	533.31	4,490
	Flatbed truck, 24′ bed	hr	14.87	157.14	2,337
Subtotal					14,138
Labor					
	Labor hours	hr	6.93**	7,165.73	49,658
	Related labor hours, 20%	hr	6.93	1,433.15	9,932
Subtotal					59,590
Interest Charge on Operating Capital	Computed at 12% on an annual basis for 6 months	%	6.0 (0.06)	97,417.00	5,845
Total Variable Costs					103,262
Variable Cost per 3-4″ Salable Plant	Units available for sale in a given year	ea		27,162.00	3.80

*Total nursery = 200 acres, with 175 acres of growing space and 25 acres in production facilities, holding and field bed area, roads, etc. Group III plants = 40 acres, with 35 acres of growing space and 5 acres in production facilities, holding and field bed area, roads, etc., 27,162 salable plants (3-4′ in height) per year.

†Quantity discounts were applied to chemicals and other items.

‡51,927 plants would be stuck in the propagation house and about 23% would be lost, leaving 39,944 for transplanting into liner beds. About 20% of the plants in the liner beds would be lost, leaving 31,955 for transplanting into the field.

**Average basic wage before withholding taxes and fringe benefits = $5.25, taxes and fringe benefits add 32% or $1.68 for a total of $6.93.

††To achieve better pest and disease control, alternative chemical usage is advisable. Alternative chemical costs were estimated at 50% of the cost of Malathion, Benomyl, and Carbaryl.

TABLE 3. Summary of Annual Fixed, Variable, and Total Costs (Dollars) of Producing Deciduous Shrubs (*Viburnum*) in the Field in Ohio, 1985.

Item	50 Acre Field Nursery* Cost	Cost per Salable Plant	Percent of Total Cost	200 Acre Field Nursery† Cost	Cost per Salable Plant	Percent of Total Cost
Fixed Cost Items						
Land and Improvements	7,061	1.14	9	21,716	.80	11
Buildings	4,740	.76	6	6,811	.25	4
Machinery and Equipment	13,173	2.12	18	25,495	.94	13
General Overhead	20,592	3.32	28	32,685	1.20	17
Interest on General Overhead, Insurance, and Taxes	1,336	.22	2	2,198	.08	1
Subtotal	46,902	7.56	63	88,905	3.27	46
Variable Cost Items						
Propagation	1,634	.26	3	2,814	.10	1
Materials	4,745	.76	6	20,875	.77	11
Machinery and Equipment	5,965	.96	8	14,138	.52	8
Labor	13,735	2.21	18	59,590	2.19	31
Interest on Operating Capital	1,565	.25	2	5,845	.22	3
Subtotal	27,644	4.44	37	103,262	3.80	54
TOTAL ANNUAL COSTS	74,546	12.00	100	192,167	7.07	100

* Total Nursery—50 acres, 40 acres of growing space, 10 acres production facilities, holding and field bed area, roads, etc. Deciduous Shrubs—10 acres, 8 acres of growing space, 2 acres production facilities, holding and field bed area roads, etc.

† Total Nursery—200 acres, 175 acres of growing space, 25 acres production facilities, holding and field bed area, roads, etc. Deciduous Shurbs—40 acres, 35 of growing space, 5 acres production facilities, holding and field bed area, roads, etc.

Individual nurserymen might well experience, or at least calculate, costs considerably different than those depicted here. Most cost differences would probably be reflected in fixed rather than variable costs. Most fixed costs are implicit and their full impact may not be calculated by established nurserymen. Budgets presented assumed new facilities, machinery, and equipment. Most nurserymen have owned their land for many years and have used machinery and equipment. For the established nursery, budgeted fixed costs on land improvements, buildings, machinery, and equipment presented here would reflect replacement rather than 'book' value of depreciated items. Our fixed costs also placed a market value on management. Many nurserymen assign little if any value on their own management when computing costs. Variable items, on the other hand, are explicit, experienced at least yearly, and easily accounted for. Variable costs presented here would be typical for the industry in Ohio and should be rather consistent regardless of age and size of the nursery.

IMPLICATIONS

Total annual costs per 3-4 foot tall salable deciduous shrub (*Viburnum*) were $12.00 in the 50-acre field nursery and $7.07 in the 200-acre field nursery. Fixed costs were $7.56 in the 50-acre nursery and $3.27 in the 200-acre for a differential of $4.29 per salable plant. Variable costs, by contrast, were $4.44 in the 50-acre and $3.80 in the 200-acre for a differential of $0.64. These plant costs assumed propagation in the nursery (nine months), liner production in beds (two years), and field growing (three years), ball and burlapped harvesting, and an average height of 3-4 foot per salable plant.

These figures demonstrated that variable costs on a salable plant basis, at least over the size range of nurseries analyzed, had a moderate reduction of about 14 percent when going from a 50-acre nursery to a 200-acre. This reduction was primarily accounted for by efficiencies gained in propagation, and machinery and equipment. Fixed costs, on the other hand, had a substantial reduction of about 57 percent as size of nursery was increased. This occurred because most of the fixed factors required to operate the 50-acre nursery, such as management, buildings, and most machinery and equipment, were also adequate to operate the 200-acre. As the size of nursery increased, costs for fixed items of production were spread over more salable units, thereby reducing the fixed cost per plant.

LITERATURE CITED

1. Taylor, Reed D., Harold H. Kneen, Elton M. Smith, David E. Hahn, and Stanley Uchida. 1986. Costs of Establishing and Operating Field Nurseries Differentiated by Size of Firm and Species of Plant in U.S.D.A. Plant Hardiness Zones Five and Six. Southern Coop. Ser. Bull. 315.

Costs of Producing Shade Trees (*Acer rubrum*) in the Field by Size of Firm in Ohio

REED D. TAYLOR, HAROLD H. KNEEN, ELTON M. SMITH, DAVID E. HAHN and STANLEY UCHIDA[1]

ABSTRACT

The study was designed to determine annual production costs for field-grown shade trees in Ohio in firms of two sizes. This objective was accomplished by synthesizing two nurseries using the conceptual framework of economic engineering. Once the nurseries were synthesized, growing space was divided into five equal parts with each part being assigned a plant group. Eight acres of growing space was allocated to shade-tree research in the 50-acre nursery while 35 acres was devoted in the 200-acre nursery. One specific species of shade tree (*Acer rubrum*) was chosen for detailed analysis.

In the space allocated, 1,869 *Acer rubrum* of 2-inch caliper could be produced annually in the 50-acre nursery and 8,177 in the 200-acre nursery. Total costs, in 1985, per salable plant were $54.58 in the 50-acre nursery and $35.61 in the 200-acre nursery.

INTRODUCTION

Shade trees, including various species of *Acer, Quercus, Faxinus, Tilia,* and *Gleditsia* are important in the Ohio landscaping business. As a group they encompass a wide range of growing habits, size, foliage, flower, and fruit colors and they can be effectively used in many ways in the landscape. It is also recognized that shade trees conserve energy. Homes that are well shaded require less artificial cooling during summer months.

The specific objective of this study was to determine annual production costs for shade trees grown in the field by two sizes of firms. This information should aid Ohio nurserymen in their decisions regarding which plants to grow and in what quantities.

MATERIALS AND METHODS

Two model firms were synthesized in the study using the conceptual framework of economic engineering wherein the 'best proven practice' was included in each model. They were synthesized based on conditions observed in the vicinity of Columbus, Ohio. The complete snthesis included: developing an appropriate production cycle; schematic drawings of the physical layout, including buildings and irrigation systems; lists of equipment and other items; a complete sequence by month and year of nursery operational steps beginning with propagation and ending with loading the finished product for wholesale distribution; and budgets for fixed and variable costs.

Data for this study were obtained from wholesale nurseries and nursery suppliers in Ohio during 1985. The basic goals in synthesizing the production facilities were to minimize labor expenses, flow and movement of plant material and equipment, water runoff, and initial investment, and to maximize the number of salable plants and keep future expansion possible. See Taylor et al. (1) for a detailed analysis of the physical plant, production system, and capital production budgets.

In the production cycle, two-year-old purchased liners were prepared and planted directly into the field. Approximately 25 percent of the crop will be harvested and sold during the fall of the fourth field production year and another 25 percent dug, overwintered (heeled in with wood chips), and sold during late winter and early spring of the fifth field production year. The remaining 50 percent of the crop will be harvested and sold during late winter and spring of the fifth field production year. After the harvest is complete, the land is left fallow and disked for weed control four times during summer months. The fields are plowed in the fall of the fifth field production year in preparation for spring planting.

A model facility was synthesized for both a 50-acre and a 200-acre field nursery. The nursery operations were assumed to produce a diverse line of nursery stock, each having its own unique production cycle. Commonly grown nursery stock was divided into five. While not all inclusive, the groups do permit developing a range of per unit costs related to input costs and cultural factors. For analytical purposes, it was assumed that each plant group would occupy 20 percent of the field growing area (i.e., 50-acre nursery = 8 acres per group, 200-acre nursery = 35 acres per group). In addition to the field-growing area, the 50-acre nursery had 10 acres and the 200-acre nursery 25 acres of production facilities including overwintering houses, propagation facilities, shipping area, holding area, liner bed area, pond, supply shed, machinery storage, machine shop, office, and rest rooms. Costs developed on shade trees (*Acer rubrum*), therefore, were based on the scale of complete nurseries, but were analyyzed on the basis of percent of total space occupied. Companion studies in this publication report on fixed costs (page 26), slow growing evergreens (page 37), and deciduous shrubs (page 45).

For detailed analysis on shade trees, one specific plant species of *Acer rubrum* was chosen. While it is recognized

[1]Associate Professor, and former graduate student, Dept. of Agricultural Economics and Rural Sociology; Professor, Dept. of Horticulture; and Professor, and graduate student, Dept of Agricultural Economics and Rural Sociology, The Ohio State University. Mr. Kneen is currently Director of Marketing, Studebaker Nurseries, Inc., New Carlisle, Ohio.

In addition to research, Drs. Taylor, Smith, and Hahn hold appointments in the Ohio Cooperative Extension Service.

that other shade trees (i.e., *Acer platanoides*) would have somewhat different requirements, it was felt that the requirements would not vary significantly in cost from the *Acer rubrum* analyzed.

Costs were calculated for all factors of production including management and invested capital. In economic terms, costs associated with factors of production supplied by owner/operators are often referred to as 'opportunity costs' or the income these factors could have received if they were employed elsewhere. For example, owners could usually be employed as managers at other nurseries, and money invested in land, buildings, irrigation systems, and equipment could have earned interest if it had been placed in financial institutions.

Capital requirements for establishing the nurseries were first determined (1). Second, capital requirements per salable plant capacity by size of nursery were established (1). Third, annual fixed costs were calculated (see page 26). Fourth, annual variable costs were determined for each of the two-sized nurseries (Tables 1-2). Fifth, summaries were made for annual fixed and variable costs according to size of nursery (Table 3). This allowed cost comparisons based on size of nursery.

Most nurseries use cash rather than accrual accounting procedures. For this reason the analyses were completed on a "cash" basis. This approach does not give a true economic picture of the cost of producing a plant since it does not take into account the time value of money from planting until harvest. The analyses do, however, give a reliable estimate of the annual cost per salable plant based upon the study's assumptions.

Total annual production costs consist of both fixed and variable factors. Fixed costs are primarily made up of implicit costs such as depreciation on buildings and equipment, interest charges (both for borrowed and equity capital), and charges for management. Many nurserymen do not adequately consider fixed costs when computing costs of production. Fixed items are often considered as residual claimants on income. For example, management is compensated if all other factors of production have been accounted for. As noted previously, annual fixed costs are discussed in greater detail in a companion article.

Variable costs include all cost factors that vary with the quantity of plants being grown at one point in time. Variable costs are explicit, obvious, and normally paid out yearly. An example of variable costs would be the liners purchased for tree production. Two costs compose the total for purchased liners. The major cost is the purchase price. While price is somewhat dependent upon quality and quantity, it was assumed that sufficient quantity would be ordered in either sized nursery to obtain the plants at the lowest possible cost. The second cost was for packing and shipping the liner from producer to purchaser. This was estimated at 10 percent of the purchase price. Variable costs were subdivided into the following categories: propagation, materials, machinery and equipment, labor, and interest on operating capital (Tables 1 and 2). Details on specific variable costs, other than liners, are included in the companion article on slow-growing evergreens (page 37).

RESULTS AND DISCUSSION

Annual fixed, variable, and total production costs of producing field-grown shade trees (*Acer rubrum*) in Ohio for 1985 are summarized in Table 3. In the 50-acre nursery, total annual costs were \$102,016 or \$54.58 per salable 2-inch caliper tree. Fixed costs totaled \$46,902 or \$25.09 per plant and made up 46 percent of total costs. Based on percentage of total costs, land and improvements made up 7 percent, buildings 5 percent, machinery and equipment 13 percent, general overhead 20 percent, and interest on general overhead, insurance, and taxes 1 percent. Variable costs totaled \$55,114 or \$29.50 per tree and made up 54 percent of total costs. Based on percentage of total costs, materials made up 30 percent, machinery and equipment 10 percent, labor 11 percent, and interest on operating capital 3 percent.

In the 200-acre nursery, total annual costs were \$291,165 or \$35.61 per salable 2-inch caliper tree. Fixed costs totaled \$88,905 or \$10.87 per plant and made up 30 percent of total costs. Based on percentage of total costs, land and improvements made up 7 percent, buildings 2 percent, machinery and equipment 9 percent, general overhead 11 percent, and interest on general overhead, insurance, and taxes 1 percent. Variable costs totaled \$202,260 or \$24.74 per tree and made up 70 percent of total costs. Based on percentage of total costs, materials made up 39 percent, machinery and equipment 9 percent, labor 18 percent, and interest on operating capital 4 percent.

Total annual costs were \$18.97 per tree more in the 50-acre nursery than in the 200-acre nursery. Of this \$18.97, \$14.22 or 75 percent, were made up of fixed costs. On a per item basis, the 200-acre nursery's advantages were \$1.12 on land and improvements, \$1.71 on buildings, \$3.94 on machinery and equipment, \$7.01 on general overhead, and 44 cents on interest for general overhead, insurance, and taxes. The \$4.76 difference for variable costs was \$2.68 for materials, \$2.27 for machinery and equipment, (-46) cents for labor, and 27 cents for interest on operating capital. It should be noted that the 46-cent differential for labor was in favor of the 50-acre nursery. In harvesting, crews would have to travel shorter distances in the smaller nursery.

In the nurseries analyzed, it cost 35 percent less to produce a 2-inch caliper tree (*Acer rubrum*) in the 200-acre nursery than in the 50-acre. While the overall reduction was 35 percent, it was 57 percent for fixed costs and only 16 percent for variable. Large-sized commercial field nurseries are able to make more efficient use of buildings, equipment, machinery, labor, and general overhead than is the case for small field nurseries.

One note of caution should be observed in comparing costs between the two sized nurseries. Each of the nurseries were analyzed based on the assumption that they would produce a diverse line of plants which included both shrubs and trees. This assumption might be unrealistic for the 50-acre nursery as a considerable amount of specialized equipment was required. It should also be noted that many operators of smaller nurseries might

TABLE 1. Variable Costs (Dollars) for Shade Trees *(Acer rubrum)* for a 50-Acre* Field Nursery in Ohio, 1985.

Item	Description	Unit	Cost per Unit† ($)	Quantity	Total Variable Cost ($)
Materials					
Burlap	54″ x 54″ squares + 24″ basket	ea	3.10	1,869.00	5,794
Twine	Nails + twine	ea	0.15	1,869.00	280
Liners	6-8′ 2 yr branched	ea	11.09	2,076.00	23,023
Strip tags	5/8″ x 7″ plastic strip tags	ea	0.02	1,869.00	37
Poultry wire	1″ for rabbit control	roll	29.00	2.00	58
Seed	Ryegrass (Kentucky 31)	lb	0.64	348.48	223
Chemicals	Custom spread, custom blend: 45-0-0, 0-44-0, 0-0-60 (fertilizer)	ton	176.00	0.90	158
	Custom spread (lime)	ton	20.00	1.60	32
	Urea, 45-0-0- (fertilizer)	ton	220.00	0.70	154
	Trifluralin 4 EC (Treflan) (herbicide)	gallon	33.49	0.40	13
	Simazine 80WP (Princep) (herbicide)	lb	3.75	16.00	60
	DCPA 75WP (Dacthal) (herbicide)	lb	6.37	47.04	300
	Malathion, 57EL (Cythion) (insecticide)	gallon	18.28	14.40	263
	Benomyl, 50WP (Benlate) (fungicide)	lb	14.17	9.60	136
	Carbaryl, 80WP (Sevin) (insecticide)	lb	6.09	24.00	146
	Other (*i.e.*, Kelthane, Captan, Di-syston, Orthene, etc.)**				272
Subtotal					30,949
Machinery and Equipment					
	Tractor, 100 hp	hr	17.00	49.84	847
	Tractor, 34 hp	hr	4.99	22.86	114
	Flatbed truck, 24′ bed	hr	14.87	125.76	1,870
	Articulated loader/3,000 lb	hr	14.81	54.89	813
	Tree spade	hr	5.30	125.79	667
	Forks	hr	0.01	54.89	1
	Plow, 3-14″	hr	6.57	1.28	8
	Disk, 8′ wide	hr	4.23	2.28	10
	Harrow, 10′ wide	hr	8.45	0.19	2
	Cultimulcher, 10′ wide	hr	24.70	0.34	8
	Spray rig with 10′ boom	hr	2.77	2.50	7
	Transplanter, 1-row (tree)	hr	0.92	37.75	35
	Permanent irrigation/well and pump 100 hp	hr	7.60	15.20	116
	In-ground irrigation—storage/ holding	hr	5.56	12.00	67
	Above-ground irrigation—storage/ holding	hr	11.05	12.00	133
	In-ground irrigation — bed/field	hr	3.13	3.20	10
	Traveler gun	hr	12.06	3.20	39
	Portable PTO pump, 40 hp	hr		(no costs budgeted)	
	Airblast sprayer	hr	1.01	19.20	19
	Mower	hr	2.98	4.36	13
	Seeder	hr	1.05	2.16	2
	Sidedresser, 2-row	hr	0.63	3.84	2
	Cultivator, 2-row	hr	0.95	4.24	4
	Wagon, 4-wheel	hr	0.48	6.10	3
	Truck, 1/2-ton pickup	hr	8.42	384.42	3,237
	Flatbed truck, 24′ bed	hr	14.87	125.76	1,870
Subtotal					9,897

*Total nursery = 50 acres, with 40 acres of growing space and 10 acres in production facilities, holding and field bed area, roads, etc. Group IV plants = 10 acres, with 8 acres of growing space and 2 acres in production facilities, holding and field bed area, roads, etc., 1,869 2″ caliper salable plants per year.

†Quantity discounts were applied to chemicals and other items.

‡Average basic wage before withholding taxes and fringe benefits = $5.25, taxes and fringe benefits add 32% or $1.68 for a total of $6.93.

**To achieve better pest and disease control, alternative chemical usage is advisable. Alternative chemical costs were estimated at 50% of the cost of Malathion, Benomyl, and Carbaryl.

TABLE 1 (continued). Variable Costs (Dollars) for Shade Trees *(Acer rubrum)* for a 50-Acre* Field Nursery in Ohio, 1985.

Item	Description	Unit	Cost per Unit† ($)	Quantity	Total Variable Cost ($)
Labor					
	Labor hours	hr	6.93‡	1,340.44	9,290
	Related labor hours, 20%	hr	6.93	268.00	1,858
Subtotal					11,148
Interest Charge on Operating Capital	Computed at 12% on an annual basis for 6 months	%	6.0 (0.06)	51,994.00	3,120
Total Variable Costs					55,114
Variable Cost per Salable Plant (2" Caliper)	Units available for sale in a given year	ea		1,869.00	29.49

*Total nursery = 50 acres, with 40 acres of growing space and 10 acres in production facilities, holding and field bed area, roads, etc. Group IV plants = 10 acres, with 8 acres of growing space and 2 acres in production facilities, holding and field bed area, roads, etc., 1,869 2" caliper salable plants per year.

†Quantity discounts were applied to chemicals and other items.

‡Average basic wage before withholding taxes and fringe benefits = $5.25, taxes and fringe benefits add 32% or $1.68 for a total of $6.93.

**To achieve better pest and disease control, alternative chemical usage is advisable. Alternative chemical costs were estimated at 50% of the cost of Malathion, Benomyl, and Carbaryl.

TABLE 2. Variable Costs (Dollars) for Shade Trees *(Acer rubrum)* for a 200-Acre* Field Nursery in Ohio, 1985.

Item	Description	Unit	Cost per Unit† ($)	Quantity	Total Variable Cost ($)
Materials					
Burlap	54" x 54" squares + 24" basket	ea	3.10	8,177.00	25,349
Twine	Nails + twine	ea	0.15	8,177.00	1,227
Liners	6-8' 2 yr branched	ea	8.68	9,086.00	78,866
Strip tags	5/8" x 7" plastic strip tags	ea	0.02	8,177.00	164
Poultry wire	1" poultry wire for rabbit control	roll	29.00	9.00	261
Seed	Ryegrass (Kentucky 31)	lb	0.64	1,524.60	976
Chemicals	Custom spread, custom blend: 45-0-0, 0-44-0, 0-0-60 (fertilizer)	ton	176.00	3.95	695
	Custom spread (lime)	ton	20.00	7.00	140
	Urea, 45-0-0 (fertilizer)	ton	220.00	3.08	678
	Trifluralin 4 EC (Treflan) (herbicide)	gallon	33.49	1.75	59
	Simazine 80WP (Princep) (herbicide)	lb	3.75	70.00	263
	DCPA 75WP (Dacthal) (herbicide)	lb	6.37	196.00	1,249
	Malathion, 57EL (Cythion) (insecticide)	gallon	18.28	63.00	1,152
	Benomyl, 50WP (Benlate) (fungicide)	lb	14.17	42.00	595
	Carbaryl, 80WP (Sevin) (insecticide)	lb	6.09	105.00	639
	Other (*i.e.,* Kelthane, Captan, Di-syston, Orthene, etc.)**				1,193
Subtotal					113,506

*Total nursery = 200 acres, with 175 acres of growing space and 25 acres in production facilities, holding and field bed area, roads, etc. Group IV plants = 40 acres, with 35 acres of growing space and 5 acres in production facilities, holding and field bed area, roads, etc. 8,177 2" caliper salable plants per year.

†Quantity discounts were applied to chemicals and other items.

‡Average basic wage before withholding taxes and fringe benefits = $5.25, taxes and fringe benefits add 32% or $1.68 for a total of $6.93.

*To achieve better pest and disease control, alternative chemical usage is advisable. Alternative chemical costs were estimated at 50% of the cost of Malathion, Benomyl, and Carbaryl.

TABLE 2 (continued). Variable Costs (Dollars) for Shade Trees *(Acer rubrum)* for a 200-Acre* Field Nursery in Ohio, 1985.

Item	Description	Unit	Cost per Unit† ($)	Quantity	Total Variable Cost ($)
Machinery and Equipment					
	Tractor, 100 hp	hr	17.00	170.82	2,904
	Tractor, 60 hp	hr	11.68	102.20	1,194
	Tractor, 34 hp	hr	4.99	88.85	443
	Articulated loader/2,000 lb	hr	6.67	108.75	725
	Articulated loader/3,000 lb	hr	14.81	108.75	1,611
	Tree spade	hr	5.30	543.07	2,878
	Forks	hr	0.01	217.49	2
	Plow, 3-14″	hr	6.57	5.60	37
	Disk, 8′ wide	hr	4.23	9.45	40
	Harrow, 10′ wide	hr	8.45	0.84	7
	Cultimulcher, 10′ wide	hr	24.70	1.47	36
	Spray rig with 10′ boom	hr	2.77	10.99	30
	Transplanter, 1-row (tree)	hr	0.92	165.20	152
	Permanent irrigation/well and pump 100 hp	hr	7.60	26.00	198
	In-ground irrigation—storage/holding	hr	5.65	12.00	68
	Above-ground irrigation—storage/holding	hr	11.05	12.00	133
	In-ground irrigation — bed/field	hr	3.13	14.00	44
	Traveler gun	hr	12.06	14.00	169
	Portable PTO pump, 40 hp	hr	3.75	3.40	13
	Airblast sprayer	hr	1.01	84.00	85
	Seeder	hr	1.05	4.76	5
	Mower	hr	2.98	19.04	57
	Sidedresser, 2-row	hr	0.63	16.80	11
	Cultivator, 2-row	hr	0.95	18.48	18
	Wagon, 4-wheel	hr	0.48	26.20	13
	Truck, 1/2-ton pickup	hr	8.42	685.20	5,769
	Flatbed truck, 24′ bed	hr	14.87	545.07	8,105
Subtotal					24,747
Labor					
	Labor hours	hr	6.93‡	6,320.04	43,789
	Related labor hours, 20%	hr	6.93	1,264.00	8,760
Subtotal					52,558
Interest Charge On Operating Capital	Computed at 12% on an annual basis for six months	%	6.0 (0.06)	190,811.00	11,449
Total Variable Costs					202,260
Variable Cost per Salable Plant (2″ Caliper)	Units available for sale in a given year	ea		8,177.00	24.74

*Total nursery = 200 acres, with 175 acres of growing space and 25 acres in production facilities, holding and field bed area, roads, etc. Group IV plants = 40 acres, with 35 acres of growing space and 5 acres in production facilities, holding and field bed area, roads, etc. 8,177 2″ caliper salable plants per year.

†Quantity discounts were applied to chemicals and other items.

‡Average basic wage before withholding taxes and fringe benefits = $5.25, taxes and fringe benefits add 32% or $1.68 for a total of $6.93.

*To achieve better pest and disease control, alternative chemical usage is advisable. Alternative chemical costs were estimated at 50% of the cost of Malathion, Benomyl, and Carbaryl.

TABLE 3. Summary of Annual Fixed, Variable, and Total Costs (Dollars) of Producing Shade Trees (*Acer rubrum*) in the Field in Ohio, 1985.

	50 Acre Field Nursery*			200 Acre Field Nursery†		
Item	**Cost**	**Cost per Salable Plant**	**Percent of Total Cost**	**Cost**	**Cost per Salable Plant**	**Percent of Total Cost**
Fixed Cost Items						
Land and Improvements	7,061	3.78	7	21,716	2.66	7
Buildings	4,740	2.54	5	6,811	.83	2
Machinery and Equipment	13,173	7.05	13	25,495	3.11	9
General Overhead	20,592	11.01	20	32,685	4.00	11
Interest on General Overhead, Insurance, and Taxes	1,336	.71	1	2,198	.27	1
Subtotal	46,902	25.09	46	88,905	10.87	30
Variable Cost Items						
Propagation	‡	‡	‡	‡	‡	‡
Materials	30,949	16.56	30	113,506	13.88	39
Machinery and Equipment	9,897	5.30	10	24,747	3.03	9
Labor	11,148	5.97	11	52,558	6.43	18
Interest on Operating Capital	3,120	1.67	3	11,449	1.40	4
Subtotal	55,114	29.50	54	202,260	24.74	70
TOTAL ANNUAL COSTS	102,016	54.58	100	291,165	35.61	100

* Total Nursery—50 acres, 40 acres of growing space, 10 acres production facilities, holding and field bed area, roads, etc. Shade Trees—10 acres, 8 acres of growing space, 2 acres production facilities, holding and field bed area roads, etc.

† Total Nursery—200 acres, 175 acres of growing space, 25 acres production facilities, holding and field bed area, roads, etc. Shade Trees—40 acres, 35 of growing space, 5 acres production facilities, holding and field bed area, roads, etc.

‡ Tree liners were purchased rather than propagated. Liner costs were included under materials.

choose a different line of equipment than that budgeted. While the equipment budgeted is labor saving, smaller nurserymen might have a surplus of family labor and thus choose less expensive, less labor saving equipment. Also, a small nursery might well operate its office out of a home.

Individual nurserymen might well experience, or at least calculate, costs considerably differently from those depicted here. Most cost differences would probably be reflected in fixed rather than variable costs. Most fixed costs are implicit and their full impact may not be calculated by established nurserymen. Budgets presented assumed new facilities, machinery, and equipment. Most nurserymen have owned their land for many years and have used machinery and equipment. For the established nursery, budgeted fixed costs on land improvements, buildings, machinery, and equipment presented here would reflect replacement rather than 'book' value of depreciated items. Presented fixed costs also assigned a market value to management. Many nurserymen place little if any value on their own management when computing costs. Variable items on the other hand, are explicit, experienced at least yearly, and easily accounted for. Variable costs presented here would be typical for the industry in Ohio and should be rather consistent regardless of age and size of the nursery.

IMPLICATIONS

Total annual costs per 2-inch caliper salable shade tree (*Acer rubrum*) were \$54.58 in the 50-acre field nursery and \$35.61 in the 200-acre field nursery. Fixed costs were \$25.09 in the 50-acre nursery and \$10.87 in the 200-acre for a differential of \$14.22 per salable plant. Variable costs were \$29.50 in the 50-acre and \$24.74 in the 200-acre for a differential of \$4.76. These plant costs assumed planting purchased liners directly in the field and field growing for four years, ball and burlapped harvesting, and an average size of 2-inch caliper per salable tree.

These figures demonstrated that variable costs on a salable plant basis, at least over the size range of nurseries analyzed, had a moderate reduction of about 16 percent when a 50-acre nursery to a 200-acre. This reduction was primarily accounted for by efficiencies gained in materials, and machinery and equipment. Fixed costs, on the other hand, had a substantial reduction of about 57 percent as size of nursery was increased. This occurred because most of the fixed factors required to operate the 50-acre nursery, such as management, buildings, and most machinery and equipment, were also adequate to operate the 200-acre nursery. As the size of nursery increased, costs for fixed items of production were spread over more salable units, thereby reducing the fixed cost per plant.

LITERATURE CITED

1. Taylor, Reed D., Harold H. Kneen, Elton M. Smith, David E. Hahn, and Stanley Uchida. 1986. Costs of Establishing and Operating Field Nurseries Differentiated by Size of Firm and Species of Plant in U.S.D.A. Plant Hardiness Zones Five and Six. Southern Coop. Ser. Bull. 315.

This page intentionally blank.

The Ohio State University
Ohio Agricultural Research and Development Center